IN-051-1I-0002
IN-051-1I-0003
IN-051-1I-0004

PERMIT APPLICATION FOR CLASS I NON-HAZARDOUS INJECTION WELL

PSI ENERGY, INC.
GIBSON GENERATING STATION
OWENSVILLE, INDIANA

SUBSURFACE PROJECT NO. 60D5675

REPORT SUBMITTED
MARCH 2005

PREPARED BY

SUBSURFACE TECHNOLOGY, INC.
SOUTH BEND, INDIANA

File: pjm/PSI-Energy-5675.permit.app

SUBSURFACE

PSI ENERGY, INC.
GIBSON GENERATING STATION
OWENSVILLE, INDIANA

CLASS I UIC PERMIT APPLICATION

SUBSURFACE

LETTER OF TRANSMITTAL

TO: Mr. Mirza Baig

Underground Injection Control Branch
USEPA Region 5

77 West Jackson Boulevard; WU-16J
Chicago, Illinois 60604-3590

DATE: 4/2/07	JOB NO.: 70F5835
ATTENTION: Mr. Mirza Baig	
RE: WDW # 1 – Duke Energy Mud Log	

WE ARE SENDING YOU

[X] Attached

[ ] Under separate cover via the following items:

[ ] Contract Documents
[ ] Purchase Order
[ ] Waiver of Lien
[ ] Laboratory Analysis Report
[ ] Certificates of Insurance
[X] Copies of Reports
[ ] Bid Form & Plans
[ ] Other -

COPIES	DATE	NO.	DESCRIPTION
1	4/2/07	70F5835	Mud Log

THESE ARE TRANSMITTED as checked below:

[ ] For Approval
[X] For Your Use
[ ] For Review and Comment
[ ] Approved As Submitted
[ ] Other:
[ ] Sign and Return
[ ] Approved As Noted
[ ] As Requested
[ ] Returned For Corrections

SIGNED: Richard W. Schildhouse

Richard W. Schildhouse
Engineer, Project Manager

RECEIVED
APR 03 2007
UIC BRANCH
EPA REGION 5

SUBSURFACE

RECEIVED

SEP 23 2005

UIC BRANCH
EPA REGION 5

LETTER OF TRANSMITTAL

TO: Mr. Mirza Baig

USEPA Region 5; UIC Branch

77 West Jackson Blvd.; WU-16J

Chicago, Illinois 60604

DATE: 9/20/05

JOB NO. 60D5728

ATTENTION: Mr. Mirza Baig

RE: Per your Request - 2 Copies of DNR Letter - NHPA

3 Copies each of Figure F-2 & M-1
3 Copies Topo Map with Well Locations
3 Copies Terra Server with Well Locations

WE ARE SENDING YOU

[X] Attached

[ ] Under separate cover via the following items:

[ ] Contract Documents   [ ] Purchase Order   [ ] Waiver of Lien

[ ] Laboratory Analysis Report   [ ] Certificates of Insurance   [ ] Copies of Reports

[ ] Bid Form & Plans   [ ] Other

COPIES	DATE	NO.	DESCRIPTION
3 Each	9/20/05	60D5728	Figure F-2 and Figure M-2
2 Each	9/20/05	60D5728	Letters from DNR - NHPA
3 Each	9/20/05	60D5728	Topo Map with Well Locations
3 Each	9/20/05	60D5728	Terra Server with Well Locations

THESE ARE TRANSMITTED as checked below:

[ ] For Approval   [ ] Sign and Return

[ ] For Your Use   [ ] Approved As Noted

[ ] For Review and Comment   [X] As Requested

[ ] Approved As Submitted   [ ] Returned For Corrections

[ ] Other:

REMARKS:

COPY TO:

SIGNED: Richard W. Schildhouse
Richard W. Schildhouse
Engineer

RW

SUBSURFACE

LETTER OF TRANSMITTAL

TO: Ms. Lisa Perenchio - WU-16J

U.S. Environmental Protection Agency

Underground Injection Control Program

77 West Jackson Blvd.

Chicago, Illinois 60604-3507

DATE: 03-09-05	JOB NO.: 60D5675
ATTENTION: Underground Injection Control Program	
RE: Class I UIC Permit Application PSI Energy, Inc. - Gibson Generating Station	

WE ARE SENDING YOU

[X] Attached

[] Under separate cover via the following items:

[] Contract Documents [] Purchase Order [] Waiver of Lien

[] Laboratory Analysis Report [] Certificates of Insurance [X] Copies of Reports

[] Bid Form & Plans [] Other -

COPIES	DATE	NO.	DESCRIPTION
1	03-09-05	60D5675	Class I UIC Permit Application - 3 wells PSI Energy, Inc. Gibson Generating Station Owensville, Indiana

THESE ARE TRANSMITTED as checked below:

[X] For Approval

[] For Your Use

[] For Review and Comment

[] Approved As Submitted

[] Other:

[] Sign and Return

[] Approved As Noted

[] As Requested

[] Returned For Corrections

REMARKS: PSI Energy, Inc. would appreciate your expediting the review of the attached application. Thank you.

SIGNED: Richard W. Schildhouse RV

Richard W. Schildhouse
Engineer, Project Manager

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INTRODUCTION

EPA UNDERGROUND INJECTION CONTROL PERMIT APPLICATION

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APPENDIX

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INTRODUCTION

PSI Energy, Inc. (PSI) is making application to the United States Environmental Protection Agency (USEPA) for a permit to drill and operate three Class I non-hazardous injection wells at their Gibson Generating Station in Owensville, Indiana. The proposed injection wells are to be used for disposal of an estimated 400 gallons per minute (total) aqueous waste from wet flue gas desulfurization units associated with a coal-fired electrical power generating facility. PSI is proposing to complete wells within a "target zone" that will include the area beginning with the Trenton formation and ending with the Mt. Simon formation. Potential shallower injection intervals were considered but ruled problematic due to numerous artificial penetrations occurring in hydrocarbon producing zones or found to be inadequately plugged to protect the underground source of drinking water (USDW).

The proposed wells will operate under the USEPA Underground Injection Control (UIC) Program (40 CFR 146). The location of the proposed facility is indicated on Figure B-1.

Enclosed in this permit application are the appropriate USEPA forms along with designated attachments. Attachments are keyed to the letter designations indicated on the standard permit application form. To ease agency review, the application has been prepared to the format outlined in the USEPA Region V Permit Application Checklist for Class I Injection Wells in Michigan/Indiana (completed checklist included in final tab).

PERMIT APPLICATION

OMB No. 2040-0042 Approval Expires 1/31/05

EPA

United States Environmental Protection Agency

Underground Injection Control Permit Application

(Collected under the authority of the Safe Drinking Water Act. Sections 1421, 1422, 40 CFR 144)

I. EPA ID Number		T/A	C
U			

Read Attached Instructions Before Starting

For Official Use Only

Application approved (mo day year)	Date received (mo day year)	Permit Number	Well ID	FINDS Number

II. Owner Name and Address

Owner Name			
PSI Energy, Inc.			
Street Address		**Phone Number**	
1000 East Main Street		(317) 838-1729	
City	**State**	**ZIP CODE**	
Plainfield	IN	46168	

III. Operator Name and Address

Owner Name			
PSI Energy, Inc.-Gibson Generating Station			
Street Address		**Phone Number**	
R. R. 1 Box 300		(812) 386-4146	
City	**State**	**ZIP CODE**	
Owensville	IN	47665	

IV. Commercial Facility	V. Ownership	VI. Legal Contact	VII. SIC Codes
☐ Yes ☒ No	☒ Private ☐ Federal ☐ Other	☒ Owner ☐ Operator	4911 Electrical Services

VIII. Well Status (Mark "x")

☐ A. Operating	Date Started (mo day year)	☐ B. Modification/Conversion	☒ C. Proposed

IX. Type of Permit Requested (Mark "x" and specify if required)

☒ A. Individual	☐ B. Area	Number of Existing Wells	Number of Proposed Wells	Name(s) of field(s) or project(s)
		0	3	Gibson Generating Station

X. Class and Type of Well (see reverse)

A. Class(es) (enter code(s))	B. Type(s) (enter code(s))	C. If class is "other" or type is code 'x,' explain	D. Number of wells per type (if area permit)
I	I	—	3

XI. Location of Well(s) or Approximate Center of Field or Project

Latitude Deg	Latitude Min	Latitude Sec	Longitude Deg	Longitude Min	Longitude Sec	Township and Range Sec	Twp	Range	1/4 Sec	Feet From	Line	Feet From	Line
-87	45	57	38	22	15	5	2S	12W	SE				

XII. Indian Lands (Mark 'x')

☐ Yes
☒ No

XIII. Attachments

(Complete the following questions on a separate sheet(s) and number accordingly; see instructions)

For Classes I, II, III, (and other classes) complete and submit on a separate sheet(s) Attachments A--U (pp 2-6) as appropriate. Attach maps where required. List attachments by letter which are applicable and are included with your application. A, B, C, D, F, H, I, J, K, L, N, O, P, Q, R, T, U

XIV. Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR 144.32)

A. Name and Title (Type or Print)	B. Phone No. (Area Code and No.)
DONALD E. FAULKNER GENERAL MANAGER, GIBSON STATION	812-386-4101
C. Signature	**D. Date Signed**
Donald E. Faulkner	2/28/05

EPA Form 7520-6 (Rev. 8-01)

ATTACHMENT A

AREA OF REVIEW METHODS

A. AREA OF REVIEW

The radius of the area of review (AOR) for non-hazardous wells was established by Environmental Protection Agency Region V Guidance as "a fixed radius of 2 miles" around the proposed well location. Since multiple wells (3) are being proposed for permit at the PSI site, the AOR was extended to include a radius of 2.125 miles following plotting of the centroid of the three wells. Due to the large size of the PSI property (property perimeter of 22 miles), the AOR primarily lies within the PSI property extending outside only to the northeast. Figure B-1 illustrates the location of the AOR, the property boundary delineation, and a line 1/4 mile outside the property boundary.

There are no wells at depths greater than 4,600 feet within the AOR, therefore, site specific geologic information is not available. Input parameters have been estimated from other wells completed in or close to the proposed geologic formations. Site specific calculations will be made after the first PSI well is drilled.

To provide a conservative estimation of the expected increase in reservoir pressure over the life of the injection wells due to injection activities, calculations were performed for the St. Peter formation - near the top of the "target zone" injection interval - an area to include the Trenton formation through the Mt. Simon formation.

Expected Increase in Reservoir Pressure

The expected increase in reservoir pressure was determined after establishing the maximum allowable surface injection pressure for the wells (MASIP). The MASIP was calculated by taking the difference between the minimum expected fracture closure pressure and the maximum expected hydrostatic pressure near the top of the injection interval. The calculation of the MASIP at the top of the St. Peter formation is presented below:

$$\begin{aligned} \text{MASIP} &= D\,(P_{\text{fracture closure}} - P_{\text{hydrostatic}}) \\ &= Z_I(G_{fc} - G_h) \\ &= 5{,}880\,[0.68 - (0.4395)] - 100^{*} \\ &= 1{,}314 \text{ psi} \end{aligned}$$

Parameter Identification, Selection and Justification for MASIP Calculation:

Z_i = Distance from Ground Level to Top of Injection Interval .... 5,880 feet
(Refer to Drawing F-1 for a Generalized Stratigraphic Column and to Drawings F-2 and F-3 for north-south and east-west regional geologic cross- sections, respectively and Drawings F-4 and F-5 for northwest-southeast and northeast-southwest localized geologic cross-sections, respectively).

G_{fc} = Minimum Fracture Closure Pressure Gradient .... 0.68 psi/ft

$$G_{fc} = \left(OB_G - PP_G\right)\left(\frac{\gamma}{1-\gamma}\right) + PP_G$$

$$G_{fc} = (1.17 - 0.435)\left(\frac{0.25}{1-0.25}\right) + 0.435 = 0.68\ psi/ft$$

OB_G = Overburden Gradient (assumed 1.17)
PP_G = Pore Pressure Gradient (assumed to be 0.435 based on drill stem tests from nearby wells)
γ = Poisson's Ratio (Appendix A-1)

G_h = Maximum hydrostatic pressure gradient .... 0.4395 psi/ft

G_h = specific gravity (weight of water x 0.52)

Specific gravity = 1.015 from laboratory analysis of typical wastestream (Appendix A-2)
Weight of water = 8.33 pounds/gallon at 68°F (Appendix A-3)
0.52 = constant to convert pounds per gallon to pounds per square inch per linear foot

* 100 psi = Safety Factor

The increase in reservoir pressure (Mt. Simon Formation) at the end of 20 years is based on the following equation:

$$\Delta P_{rise} = \frac{162.6 q \mu}{kh}\left[\log\left(\frac{kt}{\phi \mu c_t r_w^2}\right) - 3.2275\right]$$

$$= \frac{(162.6)(13{,}714)(0.48)}{(100)(100)}\left[\log\left(\frac{(100)(175{,}320)}{(0.17)(0.48)(6.8\text{x } 10^{-6})(0.36)^2}\right) - 3.2275\right]$$

$$= 1{,}194.12 \text{ psi}$$

162.6 = constant

<u>Parameter Identification, Selection and Justification for ΔP_{rise} Calculation</u>:

q = Injection Rate . . . . 13,714 bbl/day
(See Attachment H, Operating Data. The maximum expected injection rate will be 400 gal/min or 13,714 bbl/day.)

μ = Formation Fluid Viscosity . . . . 0.48 centipoise
(Appendix A-4: Chart of water viscosity at various water salinities and temperatures ["Advances in Well Test Analysis Monograph", 1977]. A bottomhole temperature of 104°F was measured at a depth of 4,528 feet in ISK Well No. 2 (Valparaiso, Indiana) on December 19, 1981. Assuming a mean temperature of 50°F, an average temperature gradient of 0.0119 °F/ft was calculated. Calculating for the deepest point of the "target injection zone", the top of the Mt. Simon estimated at 11,790 feet and the bottom of the Mt. Simon estimated at 12,390 feet, an average formation temperature of 182°F was calculated at the midpoint of the injection interval at 11,090 feet. With an apparent salinity concentration of approximately 13%, based on a formation fluid specific gravity of 1.09 (estimated), a viscosity of 0.48 cp was determined from the chart.

k = Injection Interval Permeability . . . . 100 millidarcies (estimated)

h = Effective Reservoir Height . . . . 100 feet (conservative estimate)

t = Injection Period . . . . 175,320 hours
(A conservative value of 175,320 hours [20 years x 365.25 days/year x 24 hr/day = 175,320 hours] was selected.

ϕ = Injection Interval Porosity 17%
See Appendix A-5

c_t = Total Compressibility . . . . 6.8×10^{-6} psi^{-1}
(Appendix A-6: Matrix and fluid compressibility charts, "Advances in Well Test Analysis Monograph", 1977. The total compressibility (c_t) of the formation was determined by summing the formation and water compressibilities ($c_f + c_w$). From the formation matrix compressibility chart for a consolidated sand with 13% porosity, $c_f = 4.3 \times 10^{-6}$ psi^{-1}. From the compressibility chart for a 100,000 ppm NaCl solution, $c_w = 2.5 \times 10^{-6}$ psi^{-1}.

r_w = Wellbore Radius . . . . 0.36 feet
(See Attachments L, Construction Procedures, and M, Construction Details. The injection interval will be drilled with an 8 3/4 inch bit which will provide a wellbore radius of 0.36 feet [8.75/24].)

Using the parameters identified for the previous and preceding reservoir calculations, the expected surface injection pressure can be estimated as follows:

$$P_{surface} = P_0 + \Delta P_{rise} + P_{friction} + \Delta P_{skin} - P_h$$

$$= 1{,}283 + 1{,}194 + 437 + 0 - (0.4395)(5{,}880)$$

$$= 330 \text{ psi}$$

Assuming no formation skin damage, the maximum expected surface injection pressure with 5,880 feet of 4½ inch, 11.6 lb/ft, carbon steel tubing will be 387 psi after injecting at a rate of 400 gal/min for 20 years. This expected injection pressure is approximately 70% below the calculated MASIP of 1,283 psi.

The lowermost USDW within the PSI AOR is a depth equal to mean sea level or approximately 400 feet below ground level (bgl) based on an Indiana University and Indiana Geological Survey Map that contoured the depth of the 10,000 mg/L TDS boundary for the Mississippian and Pennsylvanian aquifers in Gibson County, Indiana. Based on the USDW of 400 feet bgl and a pressure gradient of 0.04395, the pressure at the lowermost USDW would be 175.8 psi.

APPENDIX A-1

POISSON'S RATIOS

POISSON'S RATIOS

Rock Type		Poisson's Ratio
Clay, very wet		0.50
Clay		0.17
Conglomerate		0.20
Dolomite		0.21
Greywacke:	coarse	0.07
	fine	0.23
	medium	0.24
Limestone:	fine, micritic	0.28
	medium, calcarenitic	0.31
	porous	0.20
	stylolitic	0.27
	fossiliferous	0.09
	bedded fossils	0.17
	shaley	0.17
Sandstone:	coarse	0.05
	coarse, cemented	0.10
	fine	0.03
	very fine	0.04
	medium	0.06
	poorly sorted, clayey	0.24
	fossiliferous	0.01
Shale:	calcareous (<50% $CaCO_3$)	0.14
	dolomitic	0.28
	siliceous	0.12
	silty (<70% silt)	0.17
	sandy (<70% sand)	0.12
	kerogenaceous	0.25
Siltstone		0.08
Slate		0.13
Tuff:	glass	0.34

Source: Daines, Stephen K., 1980, The Prediction of Fracture Pressures for Wildcat Wells: Society of Petroleum Engineers of AIME, SPE 9254, presented at 55^{th} Annual Fall Technical Conference and Exhibition of the SPE in Dallas, Texas, September 21-24, 1980, page 7.

APPENDIX A-2

TYPICAL WASTESTREAM ANALYTICAL RESULTS - PENCOR

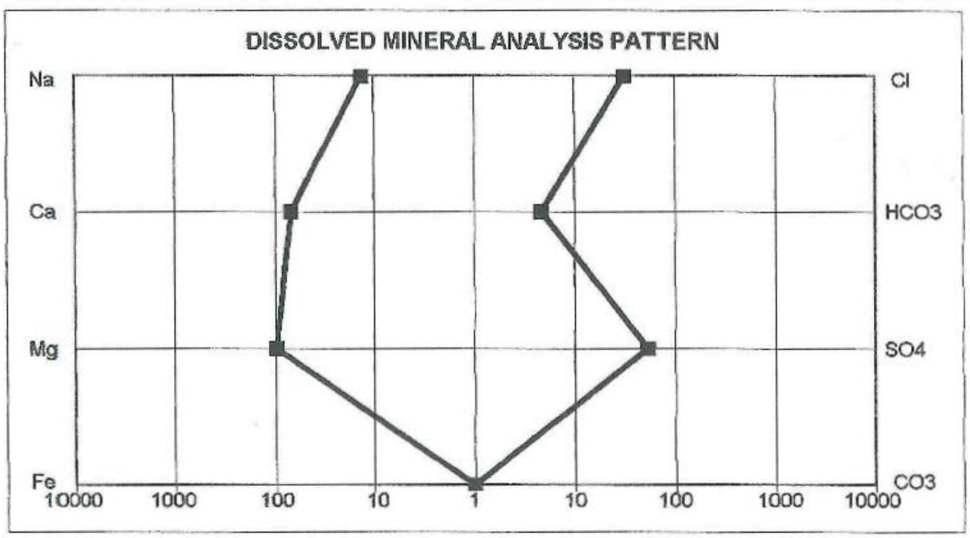
Complete Water Analysis w/ Common Metals

PENCOR ID No. 30362-01

Cations			Anions		
	mg/l	me/l		mg/l	me/l
Sodium, Na	305	13.27	Chloride, Cl	1138	32.10
Potassium, K	41	1.05	Alkalinity as HCO3	285	4.67
Calcium, Ca	1372	68.46	Carbonate, CO3	0	0.00
Magnesium, Mg	1176	96.77	Sulfate, SO4	2601	54.19
Barium, Ba	<0.005	0.00	Bromide, Br	<1.0	0.00
Iron, Fe (Dissolved)	<0.01	0.00	Iodide, I	<2.0	0.00
Iron, Fe (Total)	187	6.70	Sulfide, S	0	0.00
Additional Ions					
Boron	294.0	81.59	Nickel	0.2	0.01
Copper	0.1	0.00	Strontium	11.2	0.26
Manganese	<0.002	0.00	Zinc	<0.004	0.00
Silicon	12.6	0.90	Vanadium	0.5	0.02
Lead	<2.2	0.00	Chromium	0.3	0.01

Other Properties

pH Value @ 25 °C	6.84	Stability Index @ 100 °F	-1.13
Specific Gravity 60 / 60 °F	1.0154	Stability Index @ 200 °F	0.60
Resistivity (Ohm-Meter) @ 75 °F	0.83	% Deviation in Meq. Balance	1.58
Total Dissolved Solids, ppm	6655	% Deviation in TDS	4.89
Comments	Mercury in Wastewater = 0.0122 mg / l		



PARTSIZ^{SM} ANALYSIS

SMPL	DEPTH	Kair	SAND %						SILT %				CLAY	Vsh	Cs	MEAN	
NO	(ft)	(mD)*	GRVL	VCRS	CRS	MED	FINE	VFIN	CRS	MED	FINE	VFIN	(%)	(%)	(m2/cc)	(μ)	LITHOLOGY*
1	1.00	0.13	0.0	0.0	0.0	0.0	0.0	1.0	12.0	20.1	22.6	22.6	21.6	87	1.21	12	Shale

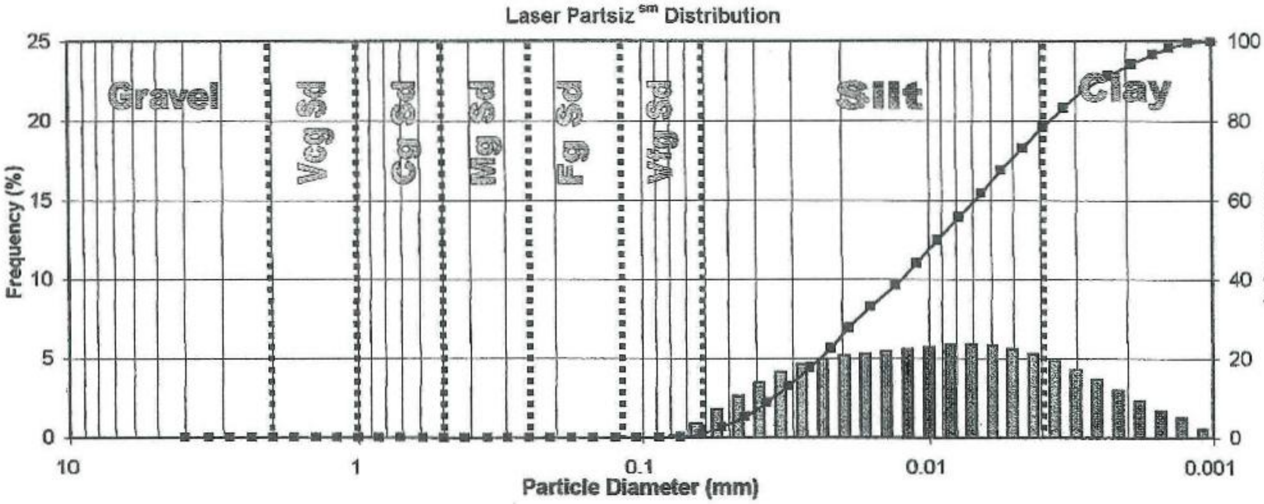
Footnotes:

* Lithology determined using laser particle size distribution.

Envirocorp Inc.
Subsurface Technologies

Hydroclone Wastewater
for the Powerplant Project
Solids at bottom of bucket

EXTENDED RANGE PARTSIZ℠ ANALYSIS



GRAIN SIZE DISTRIBUTION							
	MESH	PHI	INCH	MM	SEP	SEP	CUM
	5	-2.00	0.1575	4.0000	0.0		0.0
	6	-1.75	0.1323	3.3600	0.0		0.0
	7	-1.50	0.1114	2.8300	0.0		0.0
	8	-1.25	0.0937	2.3800	0.0		0.0
GRAVEL	10	-1.00	0.0787	2.0000	0.0	0.0	0.0
	12	-0.75	0.0661	1.6800	0.0		0.0
	14	-0.50	0.0555	1.4100	0.0		0.0
	16	-0.25	0.0469	1.1900	0.0		0.0
VCRS SD	18	0.00	0.0394	1.0000	0.0	0.0	0.0
	20	0.25	0.0335	0.8500	0.0		0.0
	25	0.50	0.0280	0.7100	0.0		0.0
	30	0.75	0.0236	0.6000	0.0		0.0
CRS SD	35	1.00	0.0197	0.5000	0.0	0.0	0.0
	40	1.25	0.0165	0.4200	0.0		0.0
	45	1.50	0.0138	0.3500	0.0		0.0
MED	50	1.75	0.0117	0.2970	0.0		0.0
SAND	60	2.00	0.0098	0.2500	0.0	0.0	0.0
	70	2.25	0.0083	0.2100	0.0		0.0
	80	2.50	0.0070	0.1770	0.0		0.0
FINE	100	2.75	0.0058	0.1490	0.0		0.0
SAND	120	3.00	0.0049	0.1250	0.0	0.0	0.0
	140	3.25	0.0041	0.1050	0.0		0.0
	170	3.50	0.0035	0.0880	0.0		0.0
VFINE	200	3.75	0.0029	0.0740	0.1		0.1
SAND	230	4.00	0.0024	0.0620	0.9	1.0	1.0
	270	4.25	0.0021	0.0530	1.8		2.8
	325	4.50	0.0017	0.0440	2.6		5.4
CRS	400	4.75	0.0015	0.0370	3.5		8.9
SILT	500	5.00	0.0014	0.0310	4.2	12.0	13.0
		5.25	0.0010	0.0260	4.7		17.7
		5.50	0.0009	0.0220	5.0		22.7
MED		5.75	0.0007	0.0190	5.2		27.8
SILT		6.00	0.0006	0.0160	5.3	20.1	33.1
		6.25	0.0005	0.0130	5.4		38.6
		6.50	0.0004	0.0110	5.6		44.2
FINE		6.75	0.0003	0.0093	5.7		49.9
SILT		7.00	0.0003	0.0078	5.8	22.6	55.8
		7.25	0.0002	0.0065	5.9		61.6
		7.50	0.0002	0.0055	5.8		67.5
VFINE		7.75	0.0002	0.0046	5.6		73.1
SILT		8.00	0.0001	0.0039	5.3	22.6	78.4
		8.25	0.0001	0.0033	4.9		83.3
		8.50	0.0001	0.0028	4.3		87.6
		8.75	0.0001	0.0023	3.7		91.2
		9.00	0.0000	0.0019	3.0		94.2
		9.25	0.0000	0.0016	2.3		96.5
		9.50	0.0000	0.0014	1.7		98.2
		9.75	0.0000	0.0012	1.2		99.5
		10.00	0.0000	0.0010	0.5	21.6	100.0

SORTING PARAMETERS

PERCENTILES:

	mm	inches	phi
5	0.0454	0.0018	4.4621
10	0.0354	0.0014	4.8209
16	0.0278	0.0011	5.1676
25	0.0206	0.0008	5.5979
50	0.0093	0.0004	6.7523
75	0.0043	0.0002	7.8453
84	0.0032	0.0001	8.2817
90	0.0025	0.0001	8.6631
95	0.0018	0.0001	9.1193

SURFACE AREA (m^2/cc) : 1.2081

STD DEVIATION (mm) : 0.0123

STD DEVIATION (inches) : 0.0005

GRAVEL PACK : N/A

	TRASK*	FOLK**	MOMENT**
MEAN	0.0125	6.7338	6.8720
MEDIAN	0.0093	6.7523	6.7523
SORTING	2.1791	1.4842	1.4243
SKEWNESS	1.0434	-0.0006	0.0328
KURTOSIS	0.2476	0.8493	2.1320

* COMPUTED USING MILLIMETER VALUES
** COMPUTED USING PHI VALUES

APPENDIX A-3

HALLIBURTON HYDROSTATIC PRESSURE AND FLUID WEIGHT CONVERSION TABLE

ENGLISH/METRIC UNITS

HYDROSTATIC PRESSURE AND FLUID WEIGHT CONVERSION TABLES

To find the Hydrostatic pressure of a column of fluid, multiply the appropriate value in Lbs./Sq. in. per foot of depth times the depth in feet.

Example: find the Hydrostatic Pressure at a depth of 13,760 feet (4 194m) in a hole filled with mud weighing 12.3 Lbs./Gal. (92.01 Lbs./Cu. Ft.) (1.474 kg/L) The value 0.6390 is found opposite 12.3 Lbs./Gal. in the table. Then 0.6390 x 13760 = 8793 Lbs. per Sq. In. (or 14.455 kPa/mX 4 194m = 60 624 kPa) hydrostatic pressure.

HYDROSTATIC PRESSURE AND FLUID WEIGHT

Lbs./Gal.	Lbs./Cu. Ft.	Sp. Gr.	Lbs./Sq. In. Per Ft. of Depth	kg/L	kPa/m
7.0	52.36	0.84	0.3636	0.839	8.225
7.1	53.11	0.85	0.3688	0.851	8.342
7.2	53.86	0.86	0.3740	0.863	8.460
7.3	54.61	0.87	0.3792	0.875	8.578
7.4	55.36	0.89	0.3844	0.887	8.695
7.5	56.10	0.90	0.3896	0.899	8.813
7.6	56.85	0.91	0.3948	0.911	8.931
7.7	57.60	0.92	0.4000	0.923	9.048
7.8	58.35	0.93	0.4052	0.935	9.166
7.9	59.10	0.95	0.4104	0.947	9.283
8.0	59.84	0.96	0.4156	0.959	9.401
8.1	60.59	0.97	0.4208	0.971	9.519
8.2	61.34	0.98	0.4260	0.983	9.636
8.3	62.09	0.99	0.4312	0.995	9.754
8.33*	62.31	1.00	0.4330	1.000	9.807
8.4	62.84	1.01	0.4364	1.007	9.872
8.5	63.58	1.02	0.4416	1.019	9.989
8.6	64.33	1.03	0.4468	1.031	10.107
8.7	65.08	1.04	0.4519	1.043	10.222
8.8	65.83	1.05	0.4571	1.054	10.340
8.9	66.58	1.07	0.4623	1.066	10.457
9.0	67.32	1.08	0.4675	1.078	10.575
9.1	68.07	1.09	0.4727	1.090	10.693
9.2	68.82	1.10	0.4779	1.102	10.810
9.3	69.57	1.11	0.4831	1.114	10.928
9.4	70.32	1.13	0.4883	1.126	11.046
9.5	71.06	1.14	0.4935	1.138	11.163
9.6	71.81	1.15	0.4987	1.150	11.281
9.7	72.56	1.16	0.5039	1.162	11.399
9.8	73.31	1.17	0.5091	1.174	11.516
9.9	74.06	1.19	0.5143	1.186	11.634
10.0	74.80	1.20	0.5195	1.198	11.751
10.1	75.55	1.21	0.5247	1.210	11.869
10.2	76.30	1.22	0.5299	1.222	11.987
10.3	77.05	1.23	0.5351	1.234	12.104
10.4	77.80	1.25	0.5403	1.246	12.222

* Density of water at 20°C.or 68°F.

SUBSURFACE

APPENDIX A-4

WATER VISCOSITY CHART AT VARIOUS SALINITIES AND TEMPERATURES

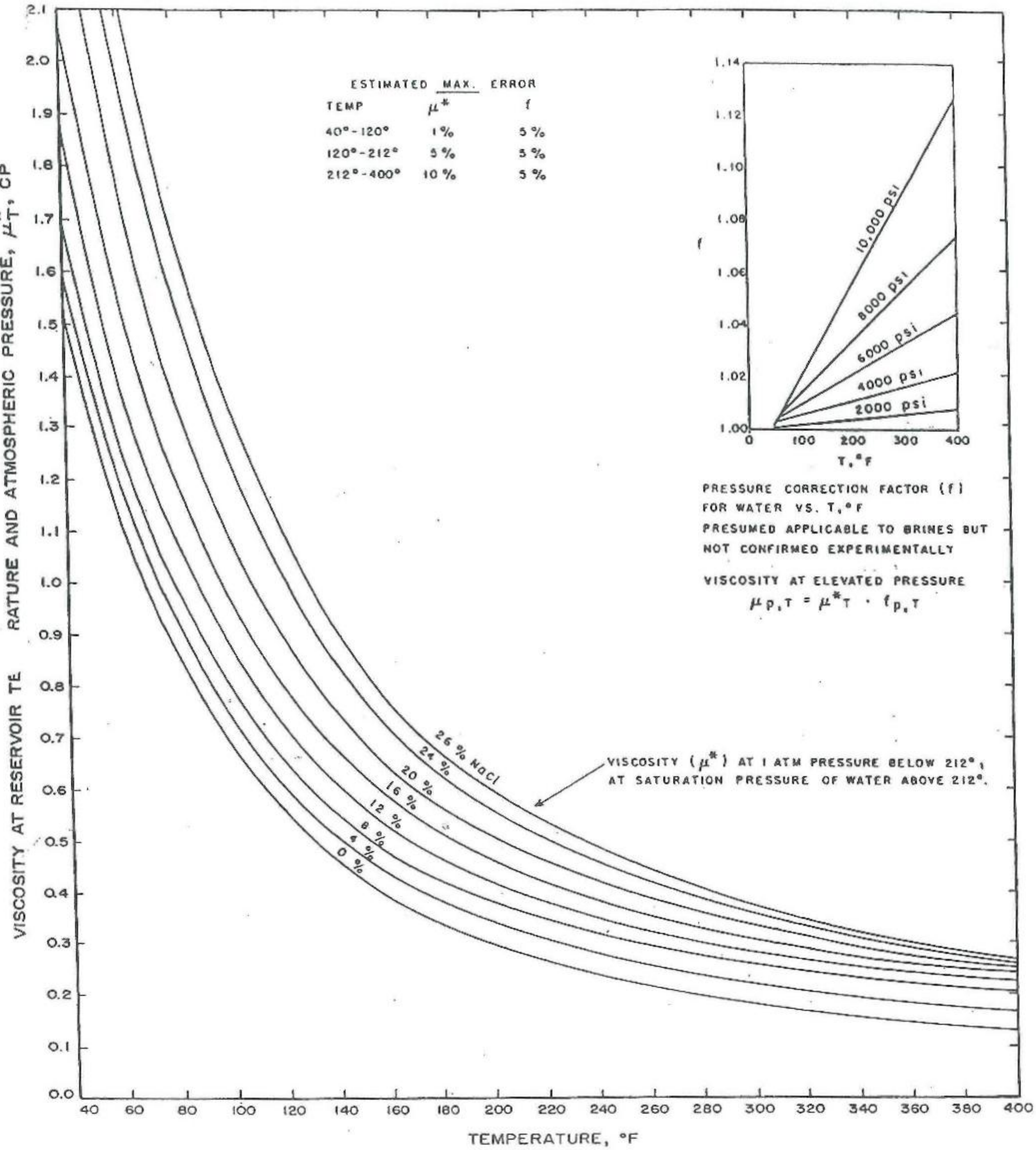


Fig. D.35 Water viscosity at various salinities and temperatures. After Matthews and Russell, data of Chesnut.[18]

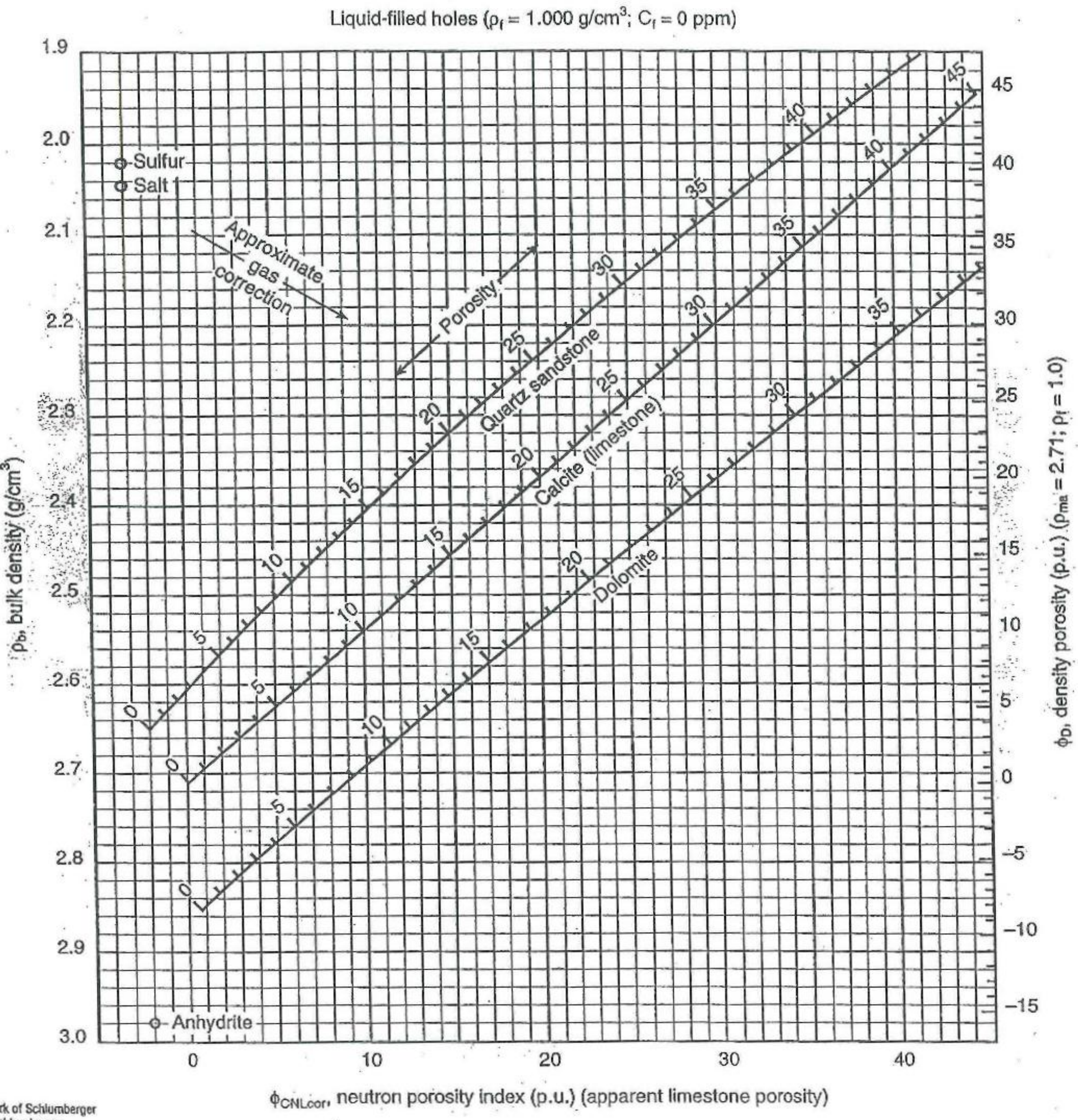
APPENDIX A-5

SCHLUMBERGER CROSSPLOT FOR POROSITY CHART: POROSITY AND LITHOLOGY DETERMINATION FROM LITHO-DENSITY AND COMPENSATED NEUTRON LOG

Porosity and Lithology Determination from Litho-Density* Log and CNL* Compensated Neutron Log

For CNL curves after 1986 labeled TNPH

CP-1e



APPENDIX A-6

MATRIX AND COMPRESSIBILITY CHARTS

SUBSURFACE

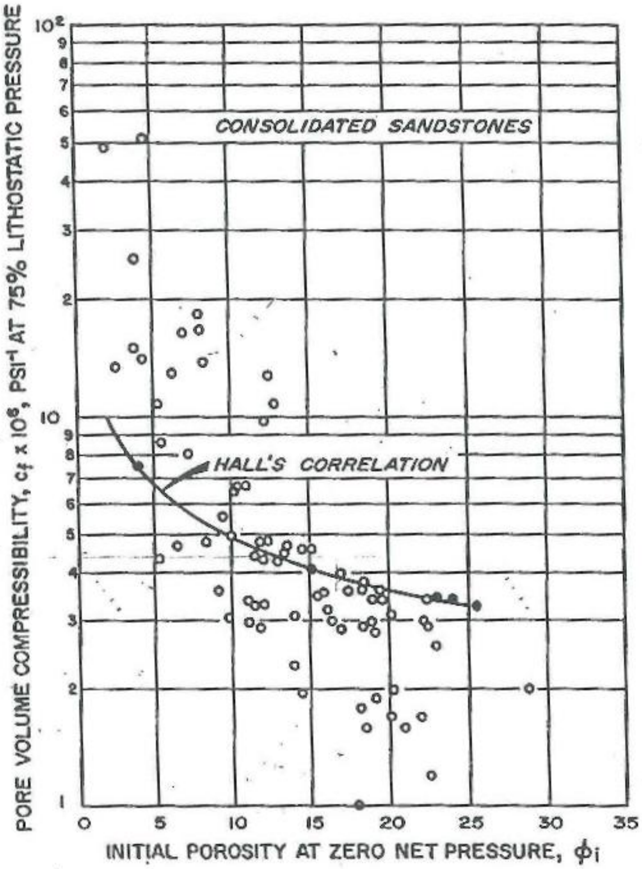


Fig. D.10 Pore-volume compressibility at 75-percent lithostatic pressure vs initial sample porosity for consolidated sandstones. After Newman.[9]

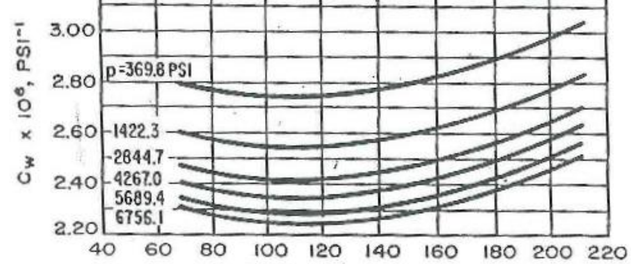


Fig. D.17 Average compressibility of 100,000-ppm NaCl in distilled water. After Long and Chierici.[13]

ATTACHMENT B

MAPS OF WELLS/AREA OF REVIEW

B. MAPS OF WELLS/AREA OF REVIEW

Maps

Figure B-1 is a copy of a U.S. Geological Survey (USGS) 7½ minute series topographic map of the area with the area of review (AOR) for the proposed injection wells identified. In addition to the AOR boundary, all freshwater and non-freshwater artificial penetrations, and RCRA TSD facilities located within the AOR, the property boundary of the facility, and all surface features are shown on subsequent figures. There are no known faults within the AOR but are located relatively nearby (Figure B-2). The boundaries of a nearby coal mine are illustrated on Figure B-3. Figures B-4 through B-7 serve as index maps indicating locations of regional and localized cross-sections found in Attachment F as Drawings F-2 through F-5.

Adjacent Land Owners

Given that the subject property encompasses a perimeter of twenty two miles, PSI respectfully requests that the requirement to supply land owner information for all properties located within one-quarter mile of the property boundary be waived by the Regional Administrator as being impracticable per 40 CFR 144.31 (e) (9).

Gibson Station area newspaper(s):

Princeton Daily Clarion
Princeton Publishing
100 N. Gibson
Princeton, IN 47670
Office: 812-385-2525
Fax: 812-386-6199
E-mail: news@pdclarion.com

Daily Republican-Register
115 East Fourth St.
P.O. Box 550
Mt. Carmel, IL 62863-0550
Telephone: (618) 262-5144
E-mail: news@mtcarmelregister.com

Hazardous Waste Treatment, Storage or Disposal (TSD) Facilities

A listing of TSD facilities in the vicinity of the PSI site was obtained from the USEPA, RCRIS National Oversite Database. No TSD facilities are located within the AOR.

Protocol for Identifying Wells

Non-Freshwater Records

Records for all oil and gas wells in the state of Indiana are maintained by the Indiana Department of Natural Resources (IDNR). The IDNR has two divisions of the agency that maintain oil and gas well records, the Division of Oil and Gas and the Indiana Geological Survey (IGS). The IDNR's Oil and Gas Division is primarily a regulatory agency that enforces compliance of oil and gas rules and regulations. Well permits, completions, and pluggings filed with this agency are maintained by county, township, range, and section number. At the IGS, all well records are filed by section, township and range.

Illinois water well records are maintained by the Illinois Geological Survey and are referenced by individual wells noted on a map rather than by section, township, and range.

Information on all non-freshwater wells located in the following sections was obtained:

- Sections 27, 28, 29, 30, 31, 32, 33, 34 and 35 Township 1 South, Range 12 West
- Sections 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21 and 22 Township 2 South, Range 12 West
- Section 36 Township 1 South, Range 13 West
- Sections 1, 12, 13 and 14 Township 2 South, Range 13 West

A total of 80 non-freshwater wells are located in the AOR. The locations of these wells are indicated on Figure B-8. Table B-1 is a listing of all dry and abandoned /or plugged wells (total 60) located within the AOR in Indiana. Table B-2 is a listing of all dry and abandoned /or plugged wells (total 17) located within the AOR in Illinois. Table B-3 is a listing of all producing wells (total 3) located within the AOR in Indiana. There are no producing wells within the AOR located in Illinois.

Sixteen (16) of the wells within the AOR are less than 2,000 feet deep. The shallowest well within the AOR is 805 feet deep and is located in the northeast 1/4 of the southeast 1/4 of Section 33, T1S, R12W. Fifty five (55) wells within the AOR are located between 2,000 and 3,000 feet deep. Nine (9) wells located within the AOR are deeper than 3,000 feet. The deepest

Table B-1
Non-Freshwater (Dry and Abandoned/or Plugged) Wells Within the AOR - Indiana

Section	Township	Range	IGS ID	Permit #	Lease Name	Well #	Total Depth	TD Formation	Status
27	1 South	12 West	128631	37415	Deep Vein Coal Co. "C" LsE.	1	2885	Salem	stratigraphic/ structure test
27	1 South	12 West	128645	39258	Marchal - State of Indiana	Unit -2	2900	Salem	abandoned oil
27	1 South	12 West	128647	36561	Noah Marchal	1	3107	Harrodsburg	dry hole
27	1 South	12 West	128650	3448	Nanney, A.A.	1	2402	Ste. Genevieve	dry hole
27	1 South	12 West	128641	38904	Kieffer, Mary	1	2435	St. Louis	abandoned oil
27	1 South	12 West	128642	38940	Keiffer, Mary	2	2904	Salem	abandoned oil
27	1 South	12 West	128646	38811	Marchal, Noah	1	3060	Harrodsburg	abandoned oil
28	1 South	12 West	128670	23895	A.M. Juttendonk Et Al	1	2413	Ste. Genevieve	dry hole
28	1 South	12 West	128671	36831	Marchal, Noah	2-ST	2985	Salem	stratigraphic/ structure test
28	1 South	12 West	128672	15781	Patoka Island Et Al	1	2977	Salem	dry hole
33	1 South	12 West	128673	16776	Alka, Kenneth	1	2413	Ste. Genevieve	dry hole
33	1 South	12 West	128674	24573	Alka, Kenneth	2	1764	Waltersburg	dry hole
33	1 South	12 West	128675	8650	Alka, Wm. G.	1	2450	Ste. Genevieve	dry hole
33	1 South	12 West	150256	371 NP	Public Service of Indiana	INA-4	805	Pennsylvanian	dry hole
34	1 South	12 West	128676	31281	Deep Vein Coal Co.	1	2800	St. Louis	dry hole
34	1 South	12 West	128677	35083	Haase Community	1	3106	Salem	dry hole
34	1 South	12 West	128678	37363	Haase, Theodore & Robert	Unit-1	3000	Salem	dry hole
34	1 South	12 West	128679	31912	Haase, Theodore	1	2394	Ste. Genevieve	dry hole
3	2 South	12 West	129914	39195	Haase, Anthony	1	3228	Harrodsburg	dry hole
3	2 South	12 West	129915	36771	Haase, Anthony	1	3119	Salem	abandoned oil
3	2 South	12 West	129916	37004	Kieffer, Lewis	1	3151	Salem	dry hole
3	2 South	12 West	129917	4325	Turner, Serena & Ed Jr.	1	2313	Paoli (Renault)	dry hole
4	2 South	12 West	130015	3374	Clayton, Clarence L.	2	2578	St. Louis	dry hole
4	2 South	12 West	130016	8749	Keith, Mildred	1	2503	Ste. Genevieve	dry hole
5	2 South	12 West	130017	27333	Beuligman, Eugene Et Al	1	2482	Ste. Genevieve	dry hole
5	2 South	12 West	130018	6316	Bueligman, Henry	1	2195	Cypress	dry hole

Table B-1
Non-Freshwater (Dry and Abandoned/or Plugged) Wells Within the AOR - Indiana

Section	Township	Range	IGS ID	Permit #	Lease Name	Well #	Total Depth	TD Formation	Status
5	2 South	12 West	130019	15972	Saylor, Vasper	1	2152	Cypress	dry hole
7	2 South	12 West	130020	6103	Barclay, Nicholas	1	2165	Big Clifty (Jackson)	dry hole
7	2 South	12 West	130021	18663	Krieg, Columbus Et Al	1	1894	Waltersburg	dry hole
7	2 South	12 West	130022	24308	Krieg, Columbus	1	1140	Pennsylvanian	dry hole
7	2 South	12 West	130023	20217	McGaughey & Krieg	1-Comm.	1148	Pennsylvanian	dry hole
7	2 South	12 West	130024	15823	McGaughy	3	1879	Waltersburg	dry hole
7	2 South	12 West	130025	9740	Joe Tennes	1	2654	Ste. Genevieve	dry hole
7	2 South	12 West	130026	29938	Tennes	1	1930	Tar Springs	dry hole
8	2 South	12 West	130027	1423	Davis & Redding	1	2580	Ste. Genevieve	dry hole
8	2 South	12 West	130028	11569	Davis	1	2587	Ste. Genevieve	dry hole
9	2 South	12 West	130029	7106	Keith	1	2510	Ste. Genevieve	dry hole
10	2 South	12 West	129707	1552	Bailey Heirs	1	2462	Ste. Genevieve	dry hole
10	2 South	12 West	129708	22502	Epler	1	2084	Cypress	dry hole
10	2 South	12 West	129709	22345	Miller	1	2118	Cypress	dry hole
10	2 South	12 West	129710	22250	Scott	1	2136	Cypress	dry hole
10	2 South	12 West	129711	24421	Scott	1	2120	Cypress	dry hole
10	2 South	12 West	129712	22677	Scott	2	1741	Vienna	dry hole
10	2 South	12 West	129713	31249	Scott	1	2375	Ste. Genevieve	dry hole
15	2 South	12 West	129807	32523	Braselton	1	2516	Ste. Genevieve	dry hole
15	2 South	12 West	129808	31023	Paul Braselton	1	2883	St. Louis	dry hole
15	2 South	12 West	129809	15594	Brazelton	1	2939	St. Louis	dry hole
15	2 South	12 West	129810	3299	Dunigan Et Al	1	2510	Ste. Genevieve	dry hole
16	2 South	12 West	129811	7162	Kieffer	1	2547	Ste. Genevieve	dry hole
16	2 South	12 West	129812	7004	Miller	1	2533	Ste. Genevieve	dry hole
17	2 South	12 West	129813	6864	Hull	1	2663	Ste. Genevieve	dry hole
18	2 South	12 West	129814	19392	Murnahan Et Al	1-Comm.	1980	Waltersburg	dry hole
18	2 South	12 West	129815	17395	Murnahan	1	2650	Ste. Genevieve	dry hole

Table B-1
Non-Freshwater (Dry and Abandoned/or Plugged) Wells Within the AOR - Indiana

Section	Township	Range	IGS ID	Permit #	Lease Name	Well #	Total Depth	TD Formation	Status
12	2 South	13 West	152089	9262	Lennert & State of Indiana.	I-1	2000	Waltersburg	water injection (flood)
12	2 South	13 West	152091	14764	Mcgaughey & State of Indiana.	1-comm.	1908	Waltersburg	dry hole
12	2 South	13 West	152090	15783	McGaughy	2	1885	Waltersburg	abandoned oil
12	2 South	13 West	152078	15782	Ellis	4	1892	Waltersburg	dry hole
13	2 South	13 West	152126	0	Sumners	1	1951	Waltersburg	dry hole
13	2 South	13 West	152125	6194	Smith	1	2720	Ste. Genevieve	dry hole
24	2 South	13 West	152165	6649	Moss	1	2838	St. Louis	dry hole

Table B-2
Non-Freshwater (Dry and Abandoned/or Plugged) Wells Within the AOR - Illinois

Section	Township	Range	API Number	County No.	Farm Name	Farm No.	Total Depth	TD Formation	Status
29	1 South	12 West	121850278300	2783	Kreeg John	1	2450	Not Listed	dry hole
29	1 South	12 West	121850424000	4240	Parkinson-Kreig Comm	1	2453	Not Listed	dry hole
29	1 South	12 West	121850311000	3110	Stein	1	2466	St. Louis	dry hole, oil show
31	1 South	12 West	121850153600	1536	Keneipp-Leonard	1	2555	McClosky	dry hole, oil show
31	1 South	12 West	121850193700	1937	Keneipp, Richard	1	2550	St. Genevieve	dry hole, oil show
31	1 South	12 West	121852758300	27583	Nelson & Rotramel	1	4600	Devonian	dry hole
31	1 South	12 West	121850153600	1536	Keneipp-Leonard	1	2555	McClosky	dry hole, oil show
32	1 South	12 West	121850156000	1560	Kieffer Hrs/C/	1	2512	St. Genevieve	dry hole, oil show
32	1 South	12 West	121850019901	199	Kieffer	1	3250	Not Listed	dry hole
32	1 South	12 West	121850273400	2734	Schuler Olivia	1	2500	Not Listed	dry hole
36	1 South	13 West	121850280500	2805	Hilbert Paul	1	2622	Not Listed	dry hole
36	1 South	13 West	121850505500	5055	Glick W A	1	2678	St. Louis	dry hole, oil show
6	2 South	12 West	121850213700	2137	Neuhausel Jerome	1	2595	Not Listed	dry hole
6	2 South	12 West	121850154900	1549	F Landes	1	2619	St. Genevieve	dry hole
1	2 South	13 West	121850223700	2237	Baird W B	1	1948	Not Listed	dry hole
1	2 South	13 West	121850210500	2105	Peters Bernard	1	1951	Not Listed	dry hole
1	2 South	13 West	121850150600	1506	G H Schrodt	1	2719	St. Genevieve	dry hole

Table B-3
Non-Freshwater (Producing) Wells Within the AOR - Indiana

Section	Township	Range	IGS ID	Permit #	Lease Name	Well #	Total Depth	TD Formation	Status
12	2 South	13 West	130030	42956	G.E. McGaughey	1	2687	Ste. Genevieve	Oil
12	2 South	13 West	152076	14581	Ellis, F.	2	1898	Waltersburg	Oil
12	2 South	13 West	152075	14770	Forest Ellis	1	2303	Cypress	Oil

well within the AOR is located 1.8 miles west, northwest of the injection point in the southwest 1/4 of the southwest 1/4 of the southeast 1/4 of Section 31, T1S, R12W. This well (farm name of Nelson & Rotramel [API Number 121852758300]) was drilled to a total depth of 4,600 feet deep in the Devonian.

Freshwater Records

Water well records available for the State of Indiana are maintained by the IDNR's Division of Water, in Indianapolis. The filing system used is referenced by section, township, and range. Information on all wells located in the following sections was obtained:

- Sections 27, 28, 29, 30, 31, 32, 33, 34 and 35 Township 1 South, Range 12 West
- Sections 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21 and 22 Township 2 South, Range 12 West
- Section 36 Township 1 South, Range 13 West
- Sections 1, 12, 13 and 14 Township 2 South, Range 13 West

A total of thirty nine (39) freshwater wells are located in the AOR. The locations of the wells are indicated on Figure B-9. The deepest well is 215 feet deep and is located 1.75 miles north, northwest of the injection point. The shallowest water well is 33 feet deep and is located 1.85 miles east, southeast of the injection point centroid.

FIGURES

ATTACHMENT C

CORRECTIVE ACTION PLAN AND WELL DATA

C. CORRECTIVE ACTION PLAN AND WELL DATA

The Area of Review (AOR) for the proposed PSI injection wells was established at 2.125 miles as discussed in Section A, paragraph 1. The deepest well within the AOR is located 1.8 miles west, northwest of the injection point centroid in the southeast 1/4 of the southwest 1/4 of the southwest 1/4 of Section 31, T1S, R12W. This well (Nelson & Rotramel {API Number 121852758300]) was drilled to a total depth of 4,600 feet deep in the Devonian (Appendix C-1).

No corrective action plan is required because there are no records indicating any improperly plugged artificial penetrations within the AOR that penetrate the proposed injection zone.

APPENDIX C-1

STATE OF ILLINOIS
WELL PLUGGING AFFIDAVIT

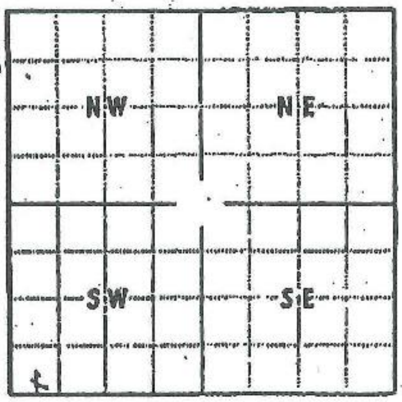
Form OG-4

STATE OF ILLINOIS }
County of Wabash } SS.

WELL PLUGGING AFFIDAVIT

Louis A. Pessina and Harold Garman being first duly sworn, do depose and say the following is a true and correct statement of the details of the plugging of a certain well drilled for Oil 12/4/12 B
(Indicate whether for oil, gas, water or other purposes)

known as the Nelson - Rotramel #1 and located as follows: 330 ft. north; ft. south; 330 ft. east; ft. west of the SW corner of the Quarter of the Quarter of the Quarter of Section [illegible], Township 1 (North or South) Range 12 (East or West), of the Principal Meridian, Wabash County, Illinois



Locate well accurately on plat of section (Scale one inch—2,000 ft.)

Elevation above sea level is { Derrick Floor 406 ft. / Ground 402 ft. }

Total depth 4600 Formation Devonian

Date permit to drill issued 6/20/86 Permit No. 38627

Permit issued to Louis A. Pessina

Date drilling began 7/11/86

Date drilling completed 7/26/86

Kind of drilling tools used Rotary

Date plugging began 7/29/86

Date plugging completed 7/29/86

WELL SITE RESTORED

Lessor Nelson - Rotramel Address Browns, Ill.

Lessee Louis A. Pessina Address Jacksonville, Ill.

Drilling Contractor A.G. Hocking Address McCarmel, Ill.

DETAILS OF PLUGGING:

		From		To	
Filled with	Cesium 137 source compensated density		4600	4564	feet
Kind of Plug	Gamma Ray log Cement, Americium 241 source compensated neutron logging tool	From	4564	4460	feet
Filled with	Deflection Cap	From	4460	4458	feet
Kind of Plug	Mud	From	4458	500	feet
Filled with	Cement	From	500	3	feet
Kind of Plug		From		To	feet
Filled with		From		To	feet
Kind of Plug	Rat Hole Cemented	From		To	feet

(Mud, Cement, or Other Materials)

IF WORKABLE COAL BEDS WERE ENCOUNTERED IN THIS HOLE, DESCRIBE THE METHOD EMPLOYED TO PROTECT SAME. (A workable coal bed is thirty inches or more in thickness above 1,000 feet in depth) Coal Plug - 500 - 3

(1) Have pits ~~and other~~ excavations been filled? .... Yes ☐ No ☒

(2) Have ~~the~~ following been removed?

Equipment Yes ☐ No ☒ Concrete bases Yes ☒ No ☐ Debris Yes ☐ No ☒

(3) ~~Has surface casing~~ been cut off three feet below ground surface? Yes ☐ No ☒

(4) Has well-site been leveled? .... Yes ☐ No ☒

If this was a producing well, give date and amount of last production D&A

CASING RECORD

	PUT IN WELL		PULLED OUT		LEFT IN WELL		
Size	Feet	Inches	Feet	Inches	Feet	Inches	Remarks
8 5/8	215				215		

Jim Barron (General Mgr.) — Louis A Pessina
(Signature of person, firm or corporation having custody or control of well.)

Per Jim Barron (General Mgr.)

Address McCarmel, Ill.

Harold Garman
(Signature and title of party supervising plugging of well.)

Address Albion, Ill.

Subscribed and sworn to before me this 7 day of August, A.D. 19 86

My commission expires 11/27/87 Mary Garman
Notary Public

County Wabash Twp. 1S R 12W Sec. 31

ATTACHMENT D

MAPS AND CROSS-SECTIONS OF USDW

D. AREA OF REVIEW MAPS AND CROSS SECTIONS OF USDW

Several freshwater and potential freshwater aquifers are present in the vicinity of the PSI facility. Figure D-1 is a generalized stratigraphic column identifying lithologies and characteristics of these aquifers. Figure D-2 is a generalized southwest to northeast cross-section showing bedrock and unconsolidated deposits.

Aquifers

Quaternary age valley-train deposits, outwash plain deposits, and Pennsylvanian age sandstone units form the principal aquifers in Gibson County. Valley-train deposits are confined to the White and Wabash River Valleys and form the most prolific aquifers (>1,000 gallons per minute [gpm]). The PSI site lies within the Wabash River valley-train deposits. Outwash plain deposits in central Gibson County may produce 300 gpm. The Inglefield Sandstone and the Busserton Sandstone form the two major Pennsylvanian aquifers. These bedrock aquifers produce between one-half and ten gpm.

Pennsylvanian Aquifers

The water availability of the alluvial aquifer is so great that water wells are rarely completed into the bedrock (Barnhart and Middleman, 1990). However, in southeastern Gibson County, where unconsolidated cover is commonly less than 20 feet thick, water production is from the underlying bedrock.

The principal bedrock aquifers in Gibson County are middle and upper Pennsylvanian fluvial and deltaic sandstones. The sandstones can occur in narrow channels or broad sheets with variable thickness. The deltaic sandstones are frequently interbedded with shales and siltstones. These sandstones have relatively low permeabilities and commonly produce four gallons per minute (gpm) (or less) of water; in many areas they constitute the only available source of drinking water. Locally, fractured limestones and coals are also used as aquifers. However, the occurrence of joints and fractures at depth is not readily predictable and they are too limited in extent to be of great importance as aquifers.

Potential aquifers in the Petersburg and Dugger Formations (Carbondale Group) are limited to localized channel and sheet sands. These channel sands were deposited with silt and mud in meandering river channels of Pennsylvanian Deltas. Wells completed in channel sandstones may produce from one to five gpm. The sheet sandstones were deposited in laterally shifting channels or as crevasse-splay deposits. These channel and sheet sandstones are limited in extend and are used as aquifers locally.

The Busseron Sandstone is the chief aquifer in the Shelburn Formation (McLeansboro Group). The Busseron Sandstone can range from 20 to 90 feet thick and is composed of gray to tan, fine to medium grained sandstone. Water yields range from one to five gpm.

The primary aquifer in the Patoka Formation is the Inglefield Sandstone member. This sandstone is light gray to buff, fine-grained, and its beds range from 20 and 40 feet thick in Gibson County. However, lateral lithologic changes limit its use as an aquifer. In abutting counties, the Inglefield Sandstone is included in an aquifer that includes the West Franklin Limestone. However, water well records in Gibson County do not indicate a good hydrologic connection. Wells completed in this sandstone may produce from three to ten gpm.

Another sandstone unit in the Patoka Formation is the Dicksburg Hills sandstone. Few wells have been completed in this unit. Most well records report this interval as sandy shale or shaly sandstone. This unit is probably too impermeable to serve as an effective aquifer in Gibson County.

The sandstones in the upper formations of the McLeansboro Group (Bond Formation and Mattoon Formation) have not been evaluated due to the lack of available data.

Unconsolidated Aquifers

The surficial deposits of Gibson County consist of Quaternary alluvial material overlying Pleistocene (predominantly of Illinoian age) till, outwash and valley train sands and gravels, and lacustrine silts and clays (Bobay, 1994). The thickness of Illinoian and Wisconsinan drift in Gibson County varies from a maximum of 140 feet along the flood plain of the Wabash to less than 10 feet in the higher elevations.

The most prolific aquifers are thick valley train sands and gravels in the Wabash River Valley. These deposits range from 30 to 100 feet thick and are laterally continuous parallel to the valley. Some water wells are capable of producing in excess of 1,000 gpm. The inter-till and outwash sands and gravels located outside of the river valleys tend to be less than 30 feet thick and are laterally discontinuous. Although wells capable of producing several hundred gpm are possible from these aquifers, production is generally much less.

Lowermost USDW

An Underground Source of Drinking Water (USDW) is defined as an aquifer or its portion which either supplies any public water system or contains a sufficient quantity of groundwater to supply a public water system. Potential Underground Sources of Drinking Water (USDW) are aquifers that can yield producible quantities of water that have total dissolved solids (TDS) less than 10,000 mg/l or ppm (parts per million). If an aquifer is not currently supplying drinking water for human consumption, it must contain fewer than 10,000 mg/L total dissolved solids (TDS) and not be an exempted aquifer to be considered a USDW. Since there are no exempted aquifers in the AOR and there are no aquifers supplying drinking water for human consumption that have a TDS above 10,000 mg/L, a USDW for the PSI AOR is considered to be any aquifer having a TDS below 10,000 mg/L.

Only reservoirs below the lowermost USDW, within an AOR, are relevant to obtaining a Class I UIC permit. The lowermost USDW within the PSI AOR is at a depth of approximately 400 feet below ground level (bgl), based on an Indiana University and Indiana Geological Survey map that contoured the depth of the 10,000 mg/L TDS boundary for the Mississippian and Pennsylvanian aquifers in Gibson County, Indiana.

To verify the depth of the lowermost USDW, an Electrical Log from a dry well four miles west-southwest of the AOR center was reviewed. The uppermost aquifer in this well was located from 295 to 335 feet bgl, which is approximately 75 feet updip from the PSI project site. From the spontaneous potential response and the drilling fluid resistivity, the formation fluid in this aquifer has a TDS of approximately 22,000 mg/L. (Appendix D-1 and D-2).

The base of the USDW at the PSI facility will be positively identified during the installation of the well through formation water sampling of the Petersburg formation. A discussion of the test procedures to be used for this program has been provided in Attachment I (Formation Testing Program) and Attachment L (Construction Procedures).

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FIGURES

APPENDICES

APPENDIX D-1

DETERMINATION OF FORMATION WATER TDS CONCENTRATION

Determination of Formation Water Total Dissolved Solids (TDS) Concentration

Given: Spontaneous Potential (E_{SSP}) of Formation = -40 mV, Mud Resistivity = 3.1 ohm-m at 56°F, Bottomhole Temperature = 98°F at 2,642 feet.

Required: Apparent TDS of Formation Water in Formation Between 300 and 340 feet below ground level.

Solution:

1) Determine Temperature of Formation
   Mean Surface Temperature = 55°F (estimated from temperature data)
   Bottomhole Temperature = 98°(measured)
   Bottomhole Depth = 2,642 feet (measured)
   Temperature Gradient = (98°F - 55°F)/2,642 feet = 0.0163°F/foot
   Formation Temperature = 55°F + 0.0163°F/foot x 320 feet = **60°F**
2) Convert Mud Resistivity to Formation Temperature
   R_m = 3.1 ohm-m @ 56°F
   R_m @ 60°F = 3.1(56 + 6.77)/(60 +6.77) = 2.9 ohm-m
3) Estimate Mud Filtrate Resistivity, R_{mf}

$$R_{mf} = K_m(R_m)^{1.07}$$
$$= 0.948(2.9)^{1.07}$$
$$= 2.96 \text{ ohm–m}$$

   Determine R_{meq}/R_{weq} from Schlumberger Chart SP-1: R_{weq} Determination from E_{SSP}
   When E_{SSP} = -40 mV and Formation Temperature = 60°F, R_{meq}/R_{weq} = 7.8
   R_{meq} = 0.85 x R_{mf} = 0.85 x 2.96 = **2.52 ohm-m**
   Solving for R_{weq}, R_{meq}/R_{weq} = 7.8 and 2.52/R_{weq} = 7.6; R_{weq} = 2.52/7.6 = **0.33 ohm-m**
4) From Schlumberger Chart SP-2: R_W versus R_{weq} and Formation Temperature
   When R_{weq} = 0.33 ohm-m and Formation Temperature = 60°F
   R_w = 0.33 ohm-m @ 60°F
5) From Schlumberger Chart Gen-9: Resistivity of NaCl Solutions
   When R_w = 0.33 ohm-m @ 60°F
   NaCl Concentration (apparent TDS) = 22,000 ppm

Summary:

1) The depth of the lowermost USDW at the well used in the calculation above is about 20 feet above mean sea level or 370 feet below ground level, based on the 10,000 TDS contour map.
2) Based on the TDS calculation performed above, the lowermost USDW appears to be above 90 feet above mean sea level (300 feet below ground level).
3) Establishing the lowermost USDW at 400 feet below ground level for the AOR is a conservative estimate based on the available information.

Table 30. Analyses in mg/L of Mount Simon brines

Sample No.*	Location	Depth in feet	60° SP. GR	Resistivity Ohm-Meter		pH	Total solids	K	Na	Ca	Sr	Mg	Total Fe	Cl	HCO_3	CO_3	Br	SO_4	H_2S
				80°	100°														
C-65-3	Lake 29-37N-8W	2469-2491	1.007			7.50	13,100	166	3,270	1,090	28	240		7,980	129.3		42	179	None
C-65-4	Lake 29-37N-8W	3316-3333	1.076			6.81	101,300	836	28,000	8,750	198	1,440	1.20	60,300	65.9		291	1,460	None
C-65-5	Lake 29-37N-8W	3793-3813	1.096			6.65	128,200	1,060	32,000	12,400	236	2,190	1.54	78,700	68.3	0	362	1,180	None
H-186	Lake 29-37N-8W	3766-3786	1.092			5.8	124,000		31,600	12,400		2,180	48	76,200				1,170	0
H-187	Lake 29-37N-8W	2384-4303	1.068			5.9	92,500		23,400	9,400		1,710	41	57,100				800	0
H-188	Lake 29-37N-8W	2384-4303	1.068			5.9	91,900		23,300	9,360		1,660	39	56,700				800	0
H-191	Lake 29-37N-8W	2442-2464	1.010			6.3	13,200		3,620	1,070		224	26	7,910				35	0
H-192	Lake 29-37N-8W	3289-3306	1.071			5.6	97,800		26,200	6,920		1,520	78	59,600				1,320	0
H-195	Lake 14-37N-9W	2582-2600	1.016			6.3	20,100		5,040	1,980		425	41	12,200				300	0
H-196	Lake 14-37N-9W	3870-3895	1.090			5.5	123,000		31,500	12,400		2,180	64	75,900				240	0
C-68-1	Porter 29-37N-6W	4250					98,000	646	27,000	8,140		1,320	NR	58,400	78.1	0		1,210	
C-60-24	Vermillion 9-16N-9W	5450-6160	1.148	.046	.038	5.0	202,100	1,380	49,000	22,100	720	2,840	138	125,000	116	0	521	508	None

Table 26. Analyses in mg/L of Joachim and St. Peter brines

Sample No.*	Location	Depth in feet	60° SP. GR.	Resistivity Ohm-Meter		pH	Total solids	K	Na	Ca	Sr	Mg	Total Fe	Cl	HCO_3	CO_3	Br	SO_4	H_2S
				80°	100°														
C-176	Cass 11-28N-1W	1358-1361			.33		14,863		3,740	1,255		307		7,200	310			2,050	
C-177	Jackson 11-5N-2E	2403-2410			.31		15,387		4,590	740		296		8,200	601			960	
C-66-14	Jefferson 22-4N-8E	1475-1515	1.006			7.54	11,600	85	3,430	476	23	213	3.9	6,340	312		28	746	
C-178	Madison 1-19N-6E	1285-1325			.37		12,817		3,660	391		466		6,880	1,168			252	
A-179	Marion 9-15N-3E				.28		16,000		4,351	777		730		9,613	1,016			16	28
C-180	Monroe 29-8N-1E	2373			.28		17,175		4,725	1,030		464		9,250	376			1,330	
C-181	Monroe 29-8N-1E	2373-2379			.29		17,503	236	4,591	901		405	12	8,812	120			1,509	
C-182	Orange 29-3N-2W	3222-3226			.18		27,444		8,260	1,220		632		15,200	232			1,900	
C-185	Tipton 21-21N-3E	1512-1520			.68		6,637		2,025	182		185		3,610	601			25	

Table 27. Analyses in mg/L of Knox brines

Sample No.*	Location	Depth in feet	60° SP. GR.	Resistivity Ohm-Meter		pH	Total solids	K	Na	Ca	Sr	Mg	Total Fe	Cl	HCO_3	CO_3	Br	SO_4	H_2S
				80°	100°														
C-63-3	Jefferson 8-3N-12E	1000-1220				7.68	5,870	50.3	1,660	221	NR	98.4	.02	3,180	195	0	10	450	None
H-189	Lake 29-37N-8W	1773-1803	1.004			6.8	4,470		1,060	390		84	8.2	1,630				1,100	
H-193	Lake LMF-37N-9W	1665-1690	1.002			7.0	2,590		487	266		62	17	440				1,100	
C-183	Monroe 29-8N-1E	2436-2443			.29		17,088	267	4,652	873		377	9	8,789	125			1,284	
C-184	Monroe 29-8N-1E	2489			.29		16,343	369	4,788	711		296	6	9,133	177			671	

Table 28. Analyses in mg/L of Eau Claire brines

Sample No.*	Location	Depth in feet	60° SP. GR.	Resistivity Ohm-Meter 80°	100°	pH	Total solids	K	Na	Ca	Sr	Mg	Total Fe	Cl	HCO_3	CO_3	Br	SO_4	H_2S
H-190	Lake 29-37N-8W	2082-2115	1.002			8.0	2,390		781	45		20	65	1,110				150	
C-65-1	Lake 29-37N-8W	1800-1830	1.003			7.84	4,750	50.5	995	396	7	112	ND	1,700	191		5	1,300	None
C-67-1	Lake 14-37N-9W	1665-1690	1.002			7.57	2,340	37	415	221	5	44.2	.55	418	175		.6	1,020	
H-194	Lake 14-37N-9W	2204-2280	1.011			7.1	1,210		320	83		20	7.6	496				140	
C-69-1	Porter 16-35N-5W	2600				7.10	90,200	840	20,100	10,100		1,510	2.81	56,700	56.1	0		881	

Table 29. Analyses in mg/L of Eau Claire and Mount Simon brines

Sample No.*	Location	Depth in feet	60° SP. GR.	Resistivity Ohm-Meter 80°	100°	pH	Total solids	K	Na	Ca	Sr	Mg	Total Fe	Cl	HCO_3	CO_3	Br	SO_4	H_2S
C-64-1	Porter 28-37N-6W	2222-4263	1.048			6.33*	68,300	610	17,400	6,040	119	1,110	21.5	41,600	97.6	0	197	1,060	None
C-64-13	Porter 25-37N-7W	2160-4259	1.041			1.73	57,800	606	14,300	5,140	114	950	145	35,500	0	0	164	895	None

APPENDIX D-2

SCHLUMBERGER GEN-9
RESISTIVITY OF NaCl SOLUTIONS

Resistivity of NaCl Solutions

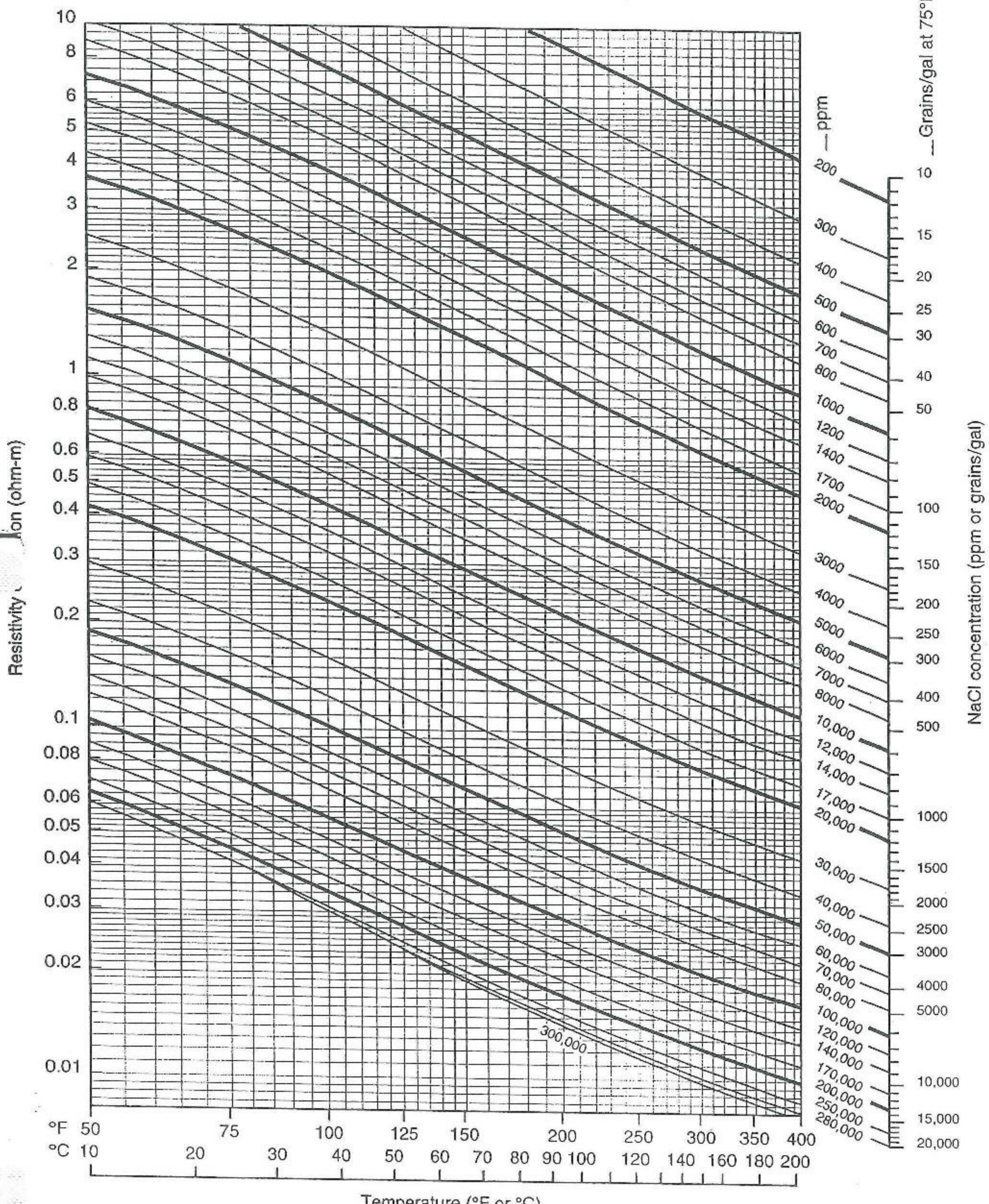
Schlumberger

Gen-9

APPENDIX D–2

Gen

Conversion approximated by $R_2 = R_1 [(T_1 + 6.77)/(T_2 + 6.77)]°F$ or $R_2 = R_1 [(T_1 + 21.5)/(T_2 + 21.5)]°C$



DOES NOT APPLY TO CLASS I WELLS

ATTACHMENT F

MAPS AND CROSS-SECTIONS OF GEOLOGIC STRUCTURE OF AREA

F. MAPS AND CROSS-SECTIONS OF GEOLOGIC STRUCTURE OF AREA

The PSI facility is located in southwestern Indiana, approximately 2.5 miles south of the town of Mount Carmel, Illinois in the Wabash River Valley. Surface elevation is approximately 390 feet above sea level. The facility is surrounded by slightly hilly terrain.

The PSI site is located approximately 55 miles north of the deepest portion of the Illinois Basin. The Illinois basin is an asymmetrical spoon-shaped structural depression that trends northwest-southeast and is filled with more than 12,000 feet of paleozoic sediment at its deepest point at the center of the basin. These sediments thin depositionally and by erosion from 2000 to 3000 feet on the arches and domes surrounding the basin. The basin is bounded to the north by the Wisconsin Arch, to the northeast by the Kankakee Arch, to the east by the Cincinnati Arch, to the south by the Pascola Arch, to the southwest by the Ozark uplift, and to the northwest by the Mississippi River Arch. The layers of sedimentary strata dip gently from these boundaries toward the deepest and thickest part of the basin known as the Fairfield Basin.

Stratigraphy and Lithology

The sedimentary rocks underlying PSI are comprised mainly of marine sediments deposited during the Paleozoic Era. Dolomite is the dominant lithology of the sedimentary rock, followed by limestone, shale, sandstone, chert, anhydrite, and coal, in that order. Igneous and metasedimentary rocks make up the Precambrian basement material which lie below the sedimentary rock. Approximately 100 feet of glacial alluvium overlies the consolidated rocks. Most geologic units underlying the PSI site dip approximately 100 feet per mile toward the southwest into the center of the Illinois Basin. A generalized stratigraphic column for Gibson County has been included as Drawing F-1. Because the AOR lies within two states, Figure F-1 is a comparative illustration of stratigraphy between the states of Illinois and Indiana. Figure F-2 is a well construction diagram showing the formation depths relative to the construction details at the Gibson Station well site.

Most geologic information is interpreted from driller's descriptions and geophysical logs run on exploration wells previously drilled in the general area. In Indiana, 24 wells have penetrated through the entire sequence of sedimentary rocks to the underlying Precambrian basement, and all but three of these wells lie along the Cincinnati and Kankakee Arches, where the depth to the basement is less than 4,600 feet. Data for the deeper rock units is therefore derived from extrapolation of geologic data from these available test wells and on interpretation of geophysical data obtained from gravity, magnetic, electrical, and seismic surveys. No wells in Gibson County Indiana or Wabash County Illinois penetrate into the Ordovician Age Knox Formation.

Records for the deepest wells in Gibson, Wabash, and surrounding counties in Indiana and Illinois, were obtained in order to extrapolate the geology at the PSI site.

The following text provides regional geologic information for the area surrounding the PSI site. A simplified stratigraphic column illustrating the estimated formation tops and thicknesses is provided in Drawing F-1. The stratigraphic nomenclature used throughout this report for Indiana was obtained from Shaver and others (1986).

Given the AOR lies within two states, geologic records were reviewed in both Indiana and Illinois. For the most part, geologic formations were similarly named in both states. However, some differences occur. The following table was created to assist the reviewer with these differences.

Indiana	Illinois
Davis Formation	Franconia Formation
Black River Group	Platteville Group
Trenton/Lexington	Galena Group
Jeffersonville/Geneva	Grand Tower
North Vernon	Lingle Formation
New Albany	Knobs Megagroup
Rockford/Chouteau	Kenderhookian Series
Borden/Sanders/Blue River	Vermeyeran Series
Renault/West Baden/Stephensport and Buffalo Wallow	Chesterian Series

Precambrian Basement

The basement complex in most of Illinois and Indiana, including the vicinity of the PSI site, has been identified as being part of the Central Granite-Rhyolite Province. The location of this province is delineated on Figure F-3. The general lithology of the Central Granite-Rhyolite Province is an anorogenic granitic or felsic intrusive terrain. Based on Figures F-4 and F-5, the Precambrian basement is thought to occur at approximately 12,000 feet and to be comprised of granite or rhyolite in the vicinity of the PSI site. No specific information is available regarding the nature of the Precambrian rocks in the vicinity of PSI.

The Cambrian System

The Cambrian System is found throughout the Illinois Basin. It is comprised, in ascending order, of the Mt. Simon Sandstone, the Munising Group, and the Potosi Dolomite. The Munising is divided into the Davis Formation and the Eau Claire Formation. Sandstones are a dominant lithology of the system, with dolomites becoming more prevalent in the upper part of the system. Figures F-6 and F-7 show that rocks of the Cambrian System in Indiana and Illinois range from less than 1,500 feet to more than 4,000 feet in thickness.

Together, the Munising and the Mt. Simon comprise the Potsdam Supergroup (Droste and Patton, 1985). Figure F-8 illustrates that the Mt. Simon ranges in thickness from less than 500 feet in eastern Indiana to more than 2,000 feet in northwestern Indiana. The Mt. Simon Sandstone is composed predominantly of immature quartz sandstones within thin zones of interbedded siltstones and shales (Becker and others, 1978). Figure F-9 illustrates the Mt. Simon in Illinois. Figure F-10 shows the Knox Supergroup in Indiana (Figure F-11, Illinois) which is both Cambrian and Ordivician. Becker and others (1978) have suggested that in southern Indiana the Davis Formation (Figure F-14) (Figure F-15, Franconia Formation in Illinois) may be absent and the Knox Supergroup may directly overlie carbonate rocks of the Eau Claire Formation (Figure F-12, Indiana - Figure F-13, Illinois).

The Cambrian Age Potosi Dolomite is considered to be the lowest member of the Knox Supergroup. The strata that constitute the Potosi Dolomite and the Eminence Formation of Illinois are traced as a single unit, while the Potosi Dolomite is traced as a single unit throughout Indiana. Figure F-16 (Indiana) (Figure F-17, Illinois) indicates that the Potosi Dolomite thickens southward with a distinctive increase in rate from central Indiana southward. Droste and Patton (1985) state that the southerly increase results in part from the downstepping of the Potosi throughout the Franconia, Ironton, and Galesville stratigraphic intervals to the place where the Potosi lies on the Eau Claire Formation.

The Ordovician System

The Ordovician System in southwestern Indiana is comprised of the Prairie du Chien Group, the Ancell Group, the Black River Group, and the Trenton Limestone. The individual group units consist of dolomites, limestones, sandstones, and shales. The Prairie du Chien Group consists of the Oneata and the Shakopee Dolomites. The Ancell Group consists of the Joachim Dolomite, the Dutchtown Formation and the St. Peter Sandstone. The Black River Group consists of the Plattin and Pecatonica Formations.

The Oneata Formation of the Prairie du Chien Group is recognized throughout most of Indiana, although it is absent due to pre-Middle Ordovician erosion in far northwestern Indiana. Figure F-18 (Indiana)(Figure F-19, Illinois) shows that the unit is thought to exceed 500 feet in thickness in southwestern Indiana. The Oneata consists predominantly of dolostone, contains modest amounts of sporadic quartz sand, and contains thin greenish shale beds, particularly near its base (Droste and Patton, 1985). The top of the Oneata is transitional into the overlying Shakopee Dolomite.

The Shakopee Dolomite is a member of the Prairie du Chien Formation. Figure F-20 (Indiana) illustrates that the thickness of the Shakopee Dolomite in Indiana ranges from 0 feet in the northern part of the state to an estimated 1,200 feet in the southwestern corner of Indiana. The Shakopee Dolomite is pure to impure and very fine-grained to fine-grained dolostone with interbeds of shale, siltstone, and sandstone. Sandstone beds as much as several tens of feet thick are present in southeastern Indiana. The Shakopee of Illinois (Figure F-21) also contains sandstones (Willman and Buschbach, 1975).

The Ancell Group ranges from 0 to more than 450 feet in thickness in Indiana, as illustrated in Figure F-23 (Figure F-22, Illinois). Droste and others (1982) state that it lies with significant unconformity on either the Knox Dolomite or the Everton Dolomite below, and is overlain by the Black River Group with sharp contact probably representing a minor erosional discontinuity. The lowermost member of the Ancell Group is the St. Peter Sandstone. The St. Peter ranges in thickness from 0 feet to over 170 feet in Indiana. Sharp differences in thickness over a few tens of miles have been observed and are thought to result from moderate relief developed along the unconformity on the subjacent Knox rocks before St. Peter deposition and because of facies changes from St. Peter rocks to Dutchtown or Joachim rocks within short distances (Droste and others, 1982). Abrupt thickening (as much as 200 additional feet is observed in some wells in northwestern Indiana) over short distances within the continuous body of the St. Peter is also known. Sinkholes, karst-solution valleys, or similar box-canyon features developed on the Knox erosion surface could be the cause of the abrupt thickening.

Generally, the St. Peter Sandstone is composed of fine to medium well-rounded and well-sorted frosted grains of quartz that are weakly cemented. In some places, secondary quartz overgrowths and siliceous intergranular cement produce well-indurated rather than friable sandstone. In southern Indiana, the St. Peter may have carbonate cement and thin interbeds of carbonate rock, generally dolomite (Droste and others, 1982). Figure F-24 illustrates the thickness of the St. Peter Sandstone in Indiana (Figure F-25, Illinois).

The Dutchtown Formation within the Ancell Group has a transitional contact with the St. Peter in the area where the Dutchtown is present. Figure F-26 (Figure F-27, Illinois) indicates the thickness and distribution of the Dutchtown in Indiana. The Dutchtown Formation in Indiana correlates with the Wells Creek Formation in Ohio. The Dutchtown is comprised of light-gray and brown partly argillaceous dolomite with some thin interbeds of green shale. In areas where the unit shows a transitional boundary with the St. Peter Sandstone, dolomite cemented medium-grained sandstone is present.

The Joachim Dolomite has the greatest subsurface distribution of the three formations of the Ancell Group (Figure F-28). The Joachim is thought to have a thickness of greater than 150 feet in southwestern Indiana. The Joachim consists of varicolored limestone and dolomite. The upper portion of the Joachim, ranging from 0 to 80 feet in thickness, contains light-colored to dark, silty to very argillaceous, and very fine-grained to fine-grained dolomite and limestone with interbedded greenish to dark-gray to black shales. Thin beds of bimodal sandstone are also present.

The Black River Group in Indiana ranges from just less than 100 feet to more than 520 feet. Figure F-29 (Figure F-30, Illinois) illustrates the thickness and distribution of the Black River Group in Indiana. Where formations of the Ancell Group are present, the Pecatonica Formation of the Black River Group overlies the Ancell with minor erosional discontinuity. The Pecatonica ranges from 30 to nearly 130 feet in thickness. Figure F-31 illustrates the thickness and distribution of the Pecatonica. In most of Indiana, the Pecatonica is comprised of grayish-brown to dark-brownish-gray lithographic limestones and fine-grained burrow-mottled limestones and dolomites. Throughout most of Indiana, a dark argillaceous limestone or silty calcareous shale zone a few feet thick is near the base of the Pecatonica.

The Plattin Formation of the Black River Group ranges from less than 100 feet to more than 400 feet in thickness in Indiana. Figure F-32 shows a gradual thickening from northwestern to southeastern Indiana, and a distinct increased thickening into southwestern Indiana. The Plattin is comprised of lithographic limestone. Beds of K-bentonite may be present.

The Plattin is overlain in Indiana by the more coarsely bioclastic carbonate rocks of the Trenton Limestone, except in parts of southeastern Indiana where rocks of the Maquoketa Group or the Lexington Limestone lie above. The Trenton has a maximum thickness of 265 feet in northeastern Indiana, and it thins to zero thickness in far southeastern Indiana (Shaver and other, 1986). Figure F-33 shows the thickness of the Trenton to be between 100 and 200 feet throughout most of central and southwestern Indiana (Figure F-34, Illinois).

The Trenton is overlain by formations of the Ordovician Age Maquoketa Group. Figure F-35 illustrates the thickness and distribution of the Maquoketa Group in Indiana (Figure F-36, Illinois). In western Indiana, the Maquoketa Group is comprised of the Scales Shale, the Fort Atkinson Limestone, and the Brainard Shale. Shaver and others (1986) believe that the contact between the Trenton and the overlying Scales Shale is a regionally time-transgressive discontinuity. The Scales Shale is commonly about 150 feet thick in western Indiana, but it thickens strikingly eastward and southeastward. The upper part is gray shale containing thin beds of limestone that become more abundant southeastward. The lower part is dominantly dark brown shale. Figure F-37 illustrates the thickness and lithofacies interpretations of the Scales Shale and its stratigraphic equivalents in Indiana.

The Fort Atkinson Limestone of the Maquoketa Group overlies the Scales Shale. The Fort Atkinson is present in the northern, central, and western portions of Indiana, and is approximately 50 feet thick over most of this area. It includes light-colored, coarsely crystalline limestone and dolomite, mainly in its upper part, and gray argillaceous limestone and calcareous shale, mainly in its lower part. Figure F-38 is a map of the thickness and lithofacies interpretations of the combined Fort Atkinson Limestone and the underlying Brainard Shale and their stratigraphic equivalents in Indiana.

The Brainard Shale is thought to conformably overlie the Fort Atkinson Limestone in northern, central, and southwestern Indiana (Shaver and others, 1986). Over most of its area of recognition, the Brainard is 75 to 100 feet thick. The Brainard consists primarily of gray to greenish-gray shale that contains a few thin interbeds of limestone. It is overlain in central and western Indiana by the Silurian Age Brassfield Limestone or Sexton Creek Limestone. Figure F-39 illustrates the structural configuration on top of the Maquoketa Group in Indiana.

The Silurian System

Over most of Indiana, rocks that unconformably overlie the Maquoketa Group are assigned to the Silurian Age Brassfield Limestone. This ranges in lithology from light-colored calcarenite in southeastern Indiana to cherty limestone to shaly limestone in southwestern Indiana. The Sexton Creek Limestone is a distinctive facies of the Brassfield present in the western half to two-thirds of Indiana. The Sexton Creek averages between 40 and 50 feet in thickness (Shaver and others, 1986).

The Sexton Creek is overlain unconformably by the St. Claire Limestone in southwestern Indiana and by the Salamonie Dolomite elsewhere in the state. In southwestern Indiana, the Salamonie has a vertical cutoff boundary with the approximate lower half of the St. Claire Limestone. The Salamonie rocks are generally impure, and include finer grained argillaceous limestone and dolomitic limestone and shale. The St. Claire is a multi-colored medium-grained limestone. The St. Claire ranges from 30 to 90 feet in thickness and averages about 60 feet in thickness in the subsurface of southwestern Indiana. The St. Claire's upper contact with the Moccasin Springs Formation generally involves an upward transition through several feet of interbedded pure limestones and argillaceous limestones (Shaver and others, 1986).

The Moccasin Springs Formation consists mostly of dense to fine-grained, somewhat argillaceous limestones that are interbedded as variably colored units. In most places, the top 20 feet of the formation consists of dark-gray to black dolomitic shale interbedded with dark-greenish-gray very fine-grained argillaceous limestone. Dark red carbonate rocks are particularly characteristic of the lower part of the formation. The Moccasin Springs has a reef facies consisting of relatively pure carbonate rocks partly in reefs that appear to have begun growth during early Moccasin Springs deposition, and partly in reefs that continued growth upward from the St. Claire Limestone. Pinnacle reefs, isolated reef growths that stand several hundred feet high and that generally cover less than one square mile, have been observed in the near by Sullivan and Vigo Counties. Figure F-40 is an isopach map of the Silurian System in Indiana, not including the Bailey Limestone (Figure F-41, Illinois). Figure F-42 indicates the locations of known reefs in southwestern Indiana. The non-reef Moccasin Springs in Indiana ranges from 60 to 140 feet in thickness.

The Moccasin Springs Formation is conformably overlain by the Bailey Limestone. The contact is placed between the darker and impurer carbonate rocks below and lighter and more neutrally colored and purer carbonate rocks above. The Bailey consists of drab, neutrally colored limestones and some dark-gray limestone. They are mostly very fine-grained, somewhat cherty, and slightly dolomitic. The Bailey has a reef and bank facies. It is believed that the Bailey reef rocks are upward continuations of reefs that began to grow in the underlying St. Claire and Mocassin Springs Formations. The Bailey's non-reef thickness is as much as 375 feet in Indiana. Figure F-43 illustrates the combined thickness of the Silurian Age deposits (Mocassin Springs Formation and the Bailey Limestone) within the Illinois Basin.

The Devonian System

Within the Illinois Basin, the Silurian Age Bailey Limestone is overlain by the New Harmony Group of the lower Devonian. Overlying Devonian Groups include the Muscatatuck Group and the New Albany Shale.

South of the Kankakee and Cincinnati Arches, the New Harmony Group is comprised of the Backbone Limestone, the Grassy Knob Chert, and the Clear Creek Chert. Within Indiana, the Grassy Knob Chert is only present in the extreme southwestern portion of Posey County. The Clear Creek Chert does not extend into the eastern portion of Gibson County. Figure F-44 illustrates the thickness and distribution of the Backbone Limestone in the Illinois Basin. In its approximately 10-county area of distribution in subsurface southwestern Indiana, the Backbone thickens southwestward from an erosional zero to a north-south elongate area of maximum thickness in the westernmost counties south of Vigo County (Shaver and others, 1986). The Backbone also thickens southward along this area, so that the thickest deposits may reach 600 feet in Posey County. Westward from this area thinning occurs basinward, probably because of a complementary relationship with the Clear Creek Chert. The Backbone is comprised of light-colored medium to coarse-grained, rather pure bioclastic limestone. The Backbone has two prominent intervals of drab cherty dolomitic limestone and dolomitic chert.

South of the Kankakee and Cincinnati Arches, the Muscatatuck Group is comprised of the Jeffersonville Limestone and the North Vernon Limestone. The Jeffersonville consists of the Dutch Creek Sandstone, Geneva Dolomite, and Vernon Fork Members. Figure F-45 illustrates the thickness and distribution of the Jeffersonville Limestone. A thin bentonite bed, named the Tioga bentonite bed, acts as a marker for the upper portion of the Jeffersonville in southwestern Indiana, including Gibson County. The Jeffersonville consists of fossiliferous limestone. The Dutch Creek Member consists of hard sandy limestone, with sand more abundant at the base of the unit. Where present, the Geneva Dolomite Member consists of brown and tan fine to medium-grained, somewhat massive, finely vuggy dolomite. Figure F-46 illustrates the thickness and distribution of the Geneva Dolomite. The Geneva is not recognized to be present in Gibson County. Figure F-47 illustrates the thickness of the Grand Tower Formation in Illinois. The Vernon Fork Dolomite in western Indiana is fine to medium-grained, finely vuggy, and mostly brown. Figure F-48 illustrates the thickness and distribution of the North Vernon Limestone. Figure F-49 illustrates the thickness of the Lingle Formation in Illinois.

The New Albany Shale conformably overlies the Muscatatuck Group in southwestern Indiana. The New Albany Shale has been divided into five members, which in ascending order are:

Blocher; Selmier; Morgan Trail; Camp Run; and Clegg Creek. The uppermost member of the New Albany Shale (Clegg Creek Member) is considered to be Mississippian in age. On the whole, the New Albany has been described as brownish-black carbon-rich shale, greenish-gray shale, and minor amounts of dolomite and dolomitic quartz sandstone (Shaver and others, 1986). Figure F-50 illustrates the thickness and distribution of the New Albany Shale in Indiana. Figure F-51 illustrates the thickness of the Knobs Megagroup in Illinois. The New Albany Shale is approximately 225 feet thick in northern Gibson County. Figure F-52 is a map showing the structure on the base of the New Albany Shale.

The Mississippian System

The Mississippian System is comprised, in ascending order, of the Clegg Creek Member of the New Albany Shale, the Borden Group, the Sanders Group, the Blue River Group, the West Baden Group, the Stephensport Group, and the Buffalo Wallow Group. The Mississippian rocks are divisible into three lithologically distinct parts. The upper part, which comprises repeated cyclic sequences of sandstone, shale, and limestone and the middle part, which consists principally of limestone of many textural varieties, are restricted to southwestern Indiana. The lower part, a clastic sequence of siltstone and shale, is present in both northern and southwestern Indiana. (Gray, 1979). Figure F-53 illustrates the distribution of both Mississippian and Pennsylvanian rocks in Indiana (Figure F-54, Illinois).

Overlying the Mississippian Age Clegg Creek Member of the New Albany Shale is the Borden Group. The Borden Group is comprised of the New Providence Shale, the Spickert Knob Formation, and the Edwardsville Formation. The Borden Group is a clastic wedge composed primarily of calcareous siltstone and shale and includes subordinate amounts of fine-grained sandstone and dolomitic limestone (Rupp, 1991). Figure F-55 illustrates the thickness and distribution of the Borden Group in Indiana (Figure F-56, Illinois). The Borden Group is thought to be approximately 0 to 25 feet thick in Gibson County.

The Sanders Group conformably overlies the Borden Group in most of southwestern Indiana. The Sanders Group is comprised of the Muldraugh Formation, the Harrodsburg Limestone, and the Salem Limestone. The Sanders Group is composed primarily of carbonate rocks. The Muldraugh Formation at the base of the group is dominantly a mixture of fine-grained dolomite and limestone with minor amounts of siltstone and shale. The overlying Harrodsburg Limestone is comprised of argillaceous limestone, dolosiltites, and shale. The Salem Limestone, except for the Somerset Shale Member at its base, is dominated by porous calcarenite, although it contains a wide variety of other kinds of limestone (Shaver and others, 1986). Oil is produced from the porous zones in the Salem Calcarenite (Keller and Becker, 1980). Figure F-57 illustrates the thickness and distribution of the Sanders Group in Indiana. Figure F-58 illustrates the structure on top of the Salem Limestone in southwestern Indiana.

The Blue River Group conformably overlies the Sanders Group in Indiana (Valmeyeran Series in Illinois, Figure F-59). The three component formations of the Blue River Group, in ascending order, are the St. Louis, Ste. Genevieve, and Paoli Limestones. The Blue River Group is formed largely of carbonate rocks, but has significant amounts of gypsum, anhydrite, shale, chert, and calcareous sandstone (Shaver and others, 1986). Figure F-60 illustrates that the thickness of the Blue River Group varies from 525 feet in northeastern Gibson County to 800 feet in southwestern Gibson County. The St. Louis Limestone of the Blue River Group contains a moderate variation of interbedded carbonate rocks, a modest number of drab thin shale beds, and in some areas zones of gypsum and anhydrite layers (Droste and Carpenter, 1990). The Ste. Genevieve Limestone is divided into three members, in ascending order, the Fredonia Member, the Karnak Member, and the Joppa Member. The Ste. Genevieve Limestone is a carbonate sequence composed largely of oolitic, skeletal, micritic, and detrital limestone. Shale, dolomite, sandstone, and chert compose about 10 percent of the combined Paoli and Ste. Genevieve Limestones (Shaver and others, 1986). The component members of the Paoli Limestone are, in ascending order, the Aux Vases Member, the Renault Member, the Yankeetown Member, and the Downeys Bluff Member. In general, the Paoli Limestone is an assortment of lighter colored carbonate rocks ranging from grainstone to mudstone with lesser amounts of interbedded shale and sandstone.

The Blue River Group is conformably overlain by the West Baden Group in southwestern Indiana. The West Baden Group consists in ascending order, of the Bethel Formation, the Beaver Bend Limestone, the Sample Formation, the Reelsville Limestone, and the Cypress Formation. The Group consists dominantly of gray to varicolored shale and mudstone and thin-bedded to crossbedded sandstone; limestone in beds of variable thickness is an important but lesser constituent (Shaver and others, 1986). Figure F-61 illustrates that the thickness of the West Baden Group in Gibson County varies between 160 and 240 feet. Much of the irregular thickness distribution of the group is caused by large clastic-filled channels that thicken and replace underlying parts of the group and the top of the carbonate rocks of the underlying Blue River Group (Rupp, 1991).

The West Baden Group is conformably overlain by the Stephensport Group in southwestern Indiana. The Stephensport consists, in ascending order, of the Beech Creek Limestone, Big Clifty Formation, Haney Limestone, Hardinsburg Formation, and the Glen Dean Limestone.

Lithologically, the units range in composition from clean shale to poorly sorted argillaceous siltstone and fine to medium-grained sandstone. Limestone within the group is predominantly coarse-grained clean bioclastic grainstones. The Stephensport Group is estimated to be approximately 175 feet thick in the vicinity of the PSI Site. Figure F-62 illustrates the thickness and distribution of the Stephensport Group in Indiana.

Where present, the Buffalo Wallow Group (Figure F-63) conformably overlies the Stephensport Group. In the subsurface, the Group is divided stratigraphically into nine units. In ascending order, these are the Tar Springs Formation, the Vienna Limestone, the Waltersburg Sandstone, the Menar Limestone, the Palestine Sandstone, the Clore Limestone, the Degonia Sandstone, the Kinkaid Limestone, and the Grove Church Shale. Buffalo Wallow rocks include predominantly shale, siltstone, and sandstone with subordinate amounts of limestone. The Buffalo Wallow is unconformably overlain throughout the basin by rocks of Pennsylvanian Age. As a result, there is progressive truncation of older rocks toward the basin margin. Figure F-64 illustrates the subcrop limit of the Buffalo Wallow Group. As can be seen from this figure, the Buffalo Wallow ranges from being absent in the northeastern portion of Gibson County to approximately 600' thick in the southwest portion of Gibson County, Indiana.

The Pennsylvanian System

The Pennsylvanian System is comprised of the Raccoon Creek, Carbondale, and McLeansboro Groups. Pennsylvanian rocks are present only in western and southwestern Indiana (Figure F-66). The division separating the Mississippian and older rocks from those of the Pennsylvanian is marked by a substantial unconformity throughout most of western and southwestern Indiana. Figure F-67 illustrates the structure on the base of the Pennsylvanian System. The unconformity has the aspect of a southwest-sloping plateau entrenched as much as 300 feet by integrated systems of southwest-trending consequent stream valleys (Gray, 1979). Because of local relief on the unconformity, Pennsylvanian rocks in any given area may rest on several older formations, but a regional trend also exists because the older rocks were slightly tilted and erosionally beveled before deposition of basal Pennsylvanian sediments. As a result, Pennsylvanian rocks rest on youngest Mississippian rocks at the southern extremity of the outcrop area and on progressively older rocks northward.

Although the Pennsylvanian System of Indiana is stratigraphically divided into three groups (Raccoon Creek, Carbondale, and McLeansboro), Rupp (1991) divided the system approximately in half for convenience of description by using the top of the Springfield Coal Member (Coal V) of the Petersburg Formation (Carbondale Group) as the plane of division. Units that compose the lower half of the system include the Mansfield, Brazil, and Staunton Formations of the Raccoon Creek Group and the Linton and Petersburg Formations of the Carbondale Group. The units are composed of alternating sequences of terrigenous to proximal marine deposits of conglomerate, sandstone, siltstone, shale, and coal, and subordinate amounts of thin limestone. Figure F-68 illustrates the structure on top of the Springfield Coal Member of the Petersburg Formation in Indiana. Figure F-69 illustrates the thickness of the lower part of the Pennsylvanian System in Indiana (Figure F-70, Illinois).

The upper part of the Pennsylvanian System conformably overlies the Springfield Coal. The Dugger Formation of the Carbondale and the Shelburn, Patoka, Bond, and Mattoon Formations of the McLeansboro comprise the upper part of the Pennsylvanian System. Figure F-71 illustrates the entire columnar section showing the nature and formation names of Pennsylvanian rocks in Indiana.

Because of extensive glaciation by Pleistocene continental ice sheets and sediment dispersal in subsequent interglacial episodes, much of the bedrock surface in Indiana has been differentially eroded. Only a small area in south central Indiana has not been directly affected by the glacial ice. Sediments representing Mesozoic and early Cenozoic time are not present in Indiana either because of non-deposition or because of complete erosional removal.

Pleistocene/Quaternary

The northern and central parts of Indiana are mantled by Pleistocene deposits of glacial and interglacial origin. These clastic sediments are primarily unconsolidated silt, sand, and gravel that are moderately to poorly sorted. Some clay-rich sediments occur as tills and lacustrine and glacial meltwater deposits. Most of the northern deposits are ice-contact sediments, but the more southerly deposits are primarily outwash or meltwater sediments.

Because of extensive glaciation by Pleistocene continental ice sheets and sediment dispersal in subsequent interglacial episodes, much of the bedrock surface in Indiana has been differentially eroded. Only a small area in south central Indiana has not been directly affected by the glacial ice. Sediments representing Mesozoic and early Cenozoic time are not present in Indiana either because of non-deposition or because of complete erosional removal.

In the Wabash River valley, the primary unconsolidated deposits consist of alluvium that overlies thick Pleistocene valley-train sand and gravel deposits. Unconsolidated deposits in the vicinity of the PSI site are approximately 100 feet thick.

Structure

Figure F-72 illustrates that the PSI site is located in the northeastern portion of the Illinois Basin. The Illinois Basin is bordered on the north by the Wisconsin Arch, and on the west by the Mississippi River Arch and the Ozark Dome. The Pascola Arch forms the southern border of the Illinois Basin, and the basin is bordered on the east and northeast by the Cincinnati Arch and the Kankakee Arch, respectively. The basin covers most of Illinois, and continues southward into Kentucky and southwest Indiana.

The PSI site lies along the southwestern limb of the LaSalle Anticlinal Belt, illustrated in Figure F-73. The LaSalle Anticlinal Belt extends from north-central Illinois southeastward into Indiana. Anticlines in the belt are asymmetrical with local dips of up to 1,000 feet per mile on the west flank. On the east flank, the dips are gentle, averaging 100 feet per mile (Clegg, 1965).

Treworgy et. al. (1989) indicate that broad and gentle differential downwarp of the Illinois Basin probably began during the late Precambrian. The most rapid subsidence occurred from the latest Precambrian to the late Cambrian. In the central portion of the Illinois Basin, the deposition of a thick blanket of nearshore marine arkosic sandstone resulted from the rapid subsidence. The tectonic subsidence is thought to be related to rifting, thermal subsidence, and an isostatically uncompensated mass in the lower crust.

The Kankakee Arch developed in early Ordovician time, separating the Illinois Basin from the Michigan Basin. In late Paleozoic time, compressive stresses acting on the Appalachians and Ouachitas were responsible for tectonic events occurring in the basin. During the Cenozoic, the surface of Indiana was finally altered to its present form by erosion and deposition associated with continental ice sheets. Seven major unconformities are recognized in southwestern Indiana. These unconformities were the result of widespread transgression and regression of the seas, erosion and tectonic events (Willman et. al., 1975). Several minor unconformities are recognized and are the result of subaerial processes.

Figure F-3 shows that the PSI site lies on the western side of the Wabash Valley Rift which is part of the Central Granite - Rhyolite Province. Figure F-74 illustrates the major faults and some anticlinal belts in the Illinois Basin. The Wabash Valley System is comprised of high angle normal faults. Displacements of this fault system have been reported to be several hundred feet (Nelson and Lumm, 1984). A portion of the Wabash Valley Fault System extends north-northeastward about 60 miles from just north of the Shawneetown Fault Zone, through Gallatin and White Counties, and terminates in Edwards and Wabash counties (Figure F-75). Spanning an area in Illinois about 15 miles wide, the fault system is characterized by generally parallel, high angle, normal faults that bound horsts and grabens.

No faults have been located within the AOR. A surface projection of the southern tip of the upper segment of the Mt. Carmel - New Harmony Fault (Part of the Wabash Valley Fault System) is about one mile west of the AOR, and it comes within 4,100 feet of the AOR as it extends north-northeastward approximately 8 more miles. A surface projection of the northern tip of the middle fault segment is located about 1.8 miles west of the AOR boundary, and it extends 21 miles in a south-southwestward direction.

The Mt. Carmel - New Harmony Fault consists of a set of three overlapping, parallel fault segments that form a single lineation. These fault segments extend in a northeasterly direction. Based on a geological study performed by the Illinois State Geological Survey Division (The Wabash Valley Fault System in Southeastern Illinois, 1979), it has been assumed that faulting in the Wabash Valley Fault System probably extends down to the basement rock since the amount of displacement at a given point along the major faults is generally constant with depth through the Pennsylvanian and Middle Mississippian formations. With the fault planes in the Wabash Valley area having dip angles ranging from 50 to 80 degrees, the projected fault traces at the basement for the middle and upper segments of the Mt. Carmel - New Harmony Fault are located between 0.6 and 1.9 miles further to the west of the AOR than the surface projections.

The northern end of the Owensville Fault is located about 7.7 miles southeast of the proposed well bore (approximately 4.4 miles southeast of the AOR boundary. The Owensville fault is the northeasternmost portion of the Wabash Valley Fault System (Zuppman and Keith, 1988). As such, it shares similar physical characteristics as the Mt. Carmel - New Harmony Fault. Based upon available structure maps of the area, the Owensville fault occurs in rocks younger than the New Harmony Group (Lower Devonian).

Most publications place the upper extent of the Owensville fault trace in Section 6, Township 3 South, Range 11 West just northeast of the town of Owensville. Based upon this location and the strike of the fault trace, the fault plane would pass approximately one quarter mile south of the southernmost extension of the AOR. However, at least one publication (Keller and Becker, 1980), shows the Owensville fault (in the Mississippian Salem Limestone) extending north-northeast and terminating in the northeast quarter of Section 20, Township 2 South, Range 11 West (estimated). Based upon the linear nature of the oil shows in the area of the fault extension, the northward extension could be correct.

Seismic Activity

Sixty-three earthquakes with intensities ranging from 2.5 to 5.5 on the Richter Scale (I to VII on the Modified Mercalli scale) have had their epicenters within 100 miles (162 kilometers) of the PSI AOR since 1827 according to the United States Geological Survey Earthquakes Hazards Program National Earthquake Information Center (See Appendix F-1). These have all been low intensity seismic events, VII or less on the Modified Mercalli Intensity Scale of 1931. The last event was reported in 2003, and was located approximately 108 km south-southeast of the facility. The quake that had an epicenter closest to the AOR (15 miles from the proposed well bore) registered 2.5 on the Richter Scale in 2000. Currently, the nearest active seismic source to the AOR is the New Madrid area of southeastern Missouri which is between 150 and 180 miles southwest of the project area. None of the recent seismic activity in the New Madrid area has approached the intensity of the 1812 quake which approached 10 on the Modified Mercalli scale.

From the study of seismicity for the region, little or no correlation has been found between tectonic features and seismicity. None of the faults in the region are active and no epicenters have been associated with them. There has been no movement along the faults in historical time, and there is no indication of any post-Paleozoic movement along the faults.

Indiana is considered a seismically-inactive state based on the seismicity studies that have been conducted in this region of the United States. The seismic risk for the AOR can be considered minimal and faults in the state have been considered tectonically inactive.

Confining Zone

The confining zone for a Class I injection well is defined as "a geological formation, group of formations, or part of a formation that is capable of limiting fluid movement above an injection zone". Very little detailed geologic information is available for geologic units located at a depth greater than 4,600 feet in the vicinity of the proposed well site (well plugging log included as Appendix C-1). Due to the lack of reservoir data, PSI prefers to have the option to locate the injection interval from the top of the Trenton Limestone to the Mt. Simon Sandstone - with a final location being determined from loss of circulation or from formation testing completed during well drilling.

Estimate Top of Maquoketa 4865

The confining zone would be the Scales Shale, Ft. Atkinson Limestone, and the Brainard Shale of the Maquoketa Group. No penetrations are known to exist through this group. These units are estimated to be approximately 225 feet thick. Additionally, there are other alternative sequences up to 3,500 feet bgs, including the New Albany Shale, which would serve as additional confinement. Only one penetration is known to occur through the New Albany Shale (the 4,600 foot well shown to be properly plugged - see Appendix C-1). Due to the presence of shales it is assumed that vertical permeability would be negligible in some or all of these units. See the previous discussion for a detailed description of these confining units.

There are no known natural or induced fractures in the Maquoketa confining zone within the AOR. Consequently, no local permeability data is available. Cores will be taken from this series (see Attachment I for details) in the proposed well to verify the confining properties of the formation.

Injection Zone

The injection zone for a Class I injection well is defined as "a geological formation, group of formations, or part of a formation receiving fluids through a well". As mentioned previously, very little detailed information is available for geologic units located at a depth greater than 4,600 feet in the vicinity of the proposed well site. Due to the lack of reservoir data, PSI prefers to have the option to locate the injection interval from the top of the Trenton Limestone (top at 5,090 feet bgs) to the Mt. Simon Sandstone (bottom at 10,600 feet bgs) - with a final location being determined from loss of circulation or from formation testing completed during well drilling. All of the formations are present throughout the area. Refer to previously mentioned figures for isopach maps of each formation showing the thickness and continuity of the formation across Indiana.

There are no known natural or induced fractures in the proposed injection zone within the AOR.

Potential shallower injection intervals were considered but ruled problematic due to numerous artificial penetrations occurring in hydrocarbon producing zones or found to be inadequately plugged to protect the underground source of drinking water (USDW).

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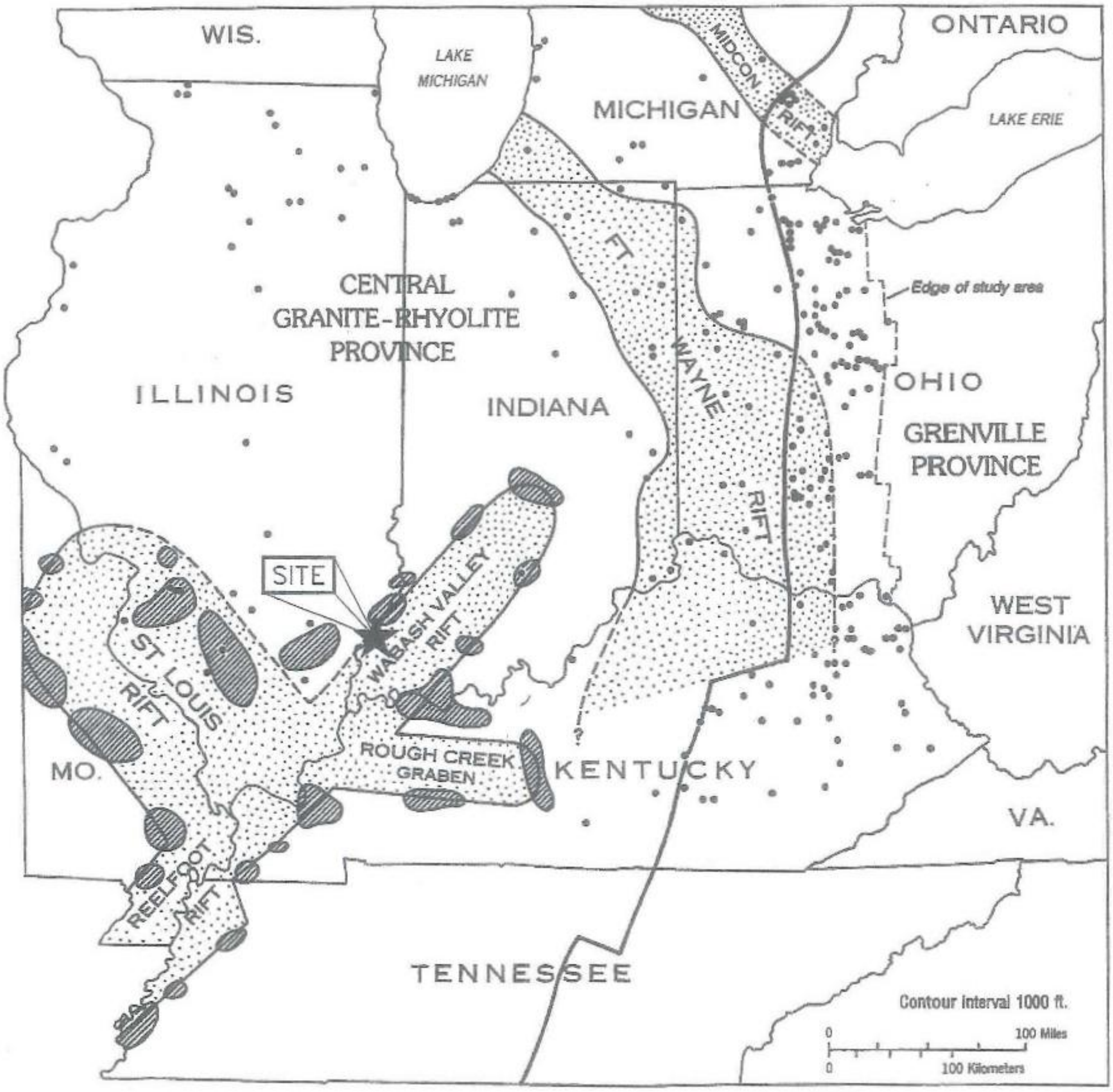
FIGURES



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–3

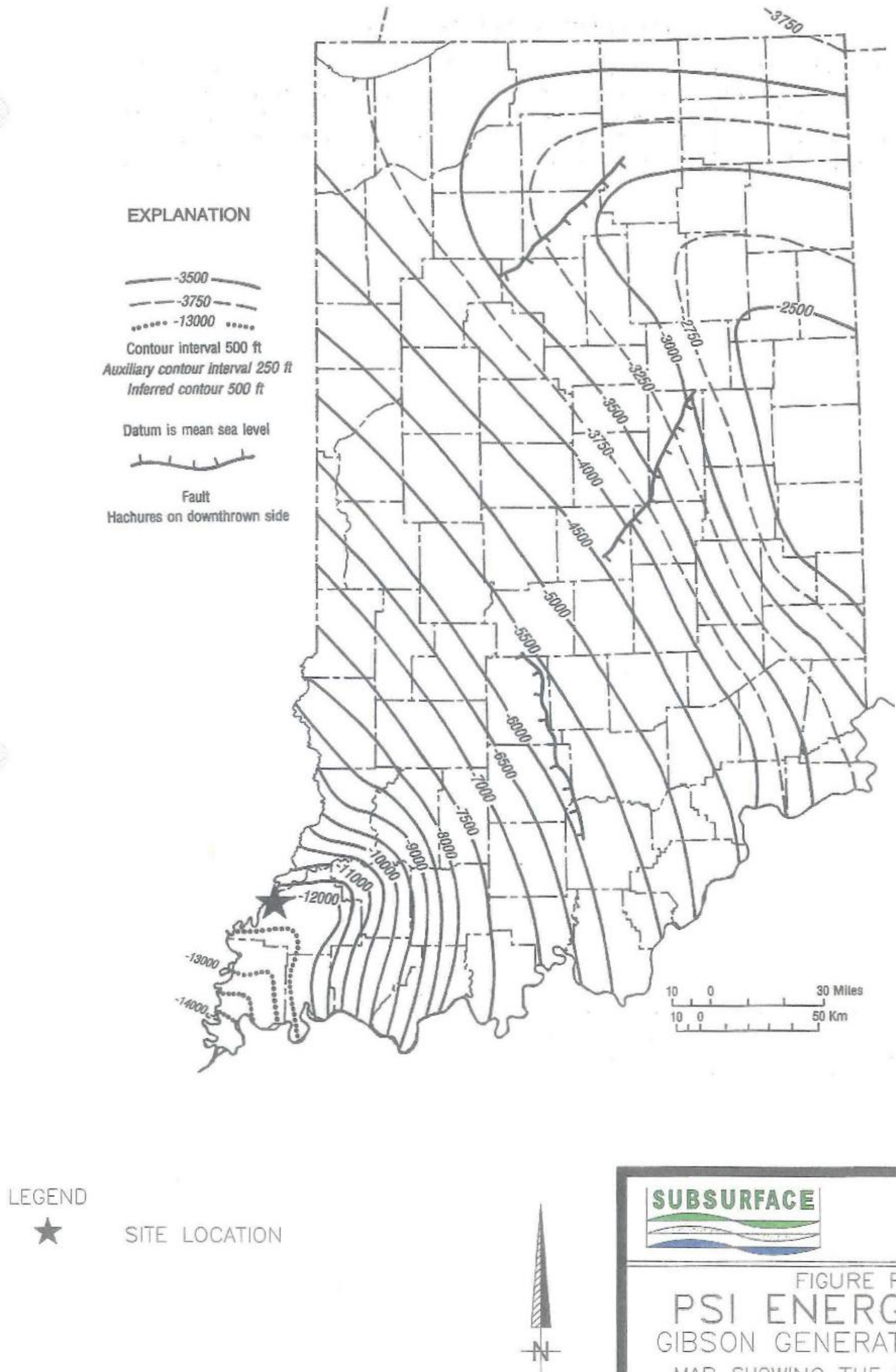
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP OF THE MIDWEST SHOWING THE LOCATIONS OF BASEMENT TESTS AND INTERPRETED PROVINCES BASED ON LITHOGRAPHY

DATE: 12/30/04	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUDMAN AND RUPP, 1993



SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–4

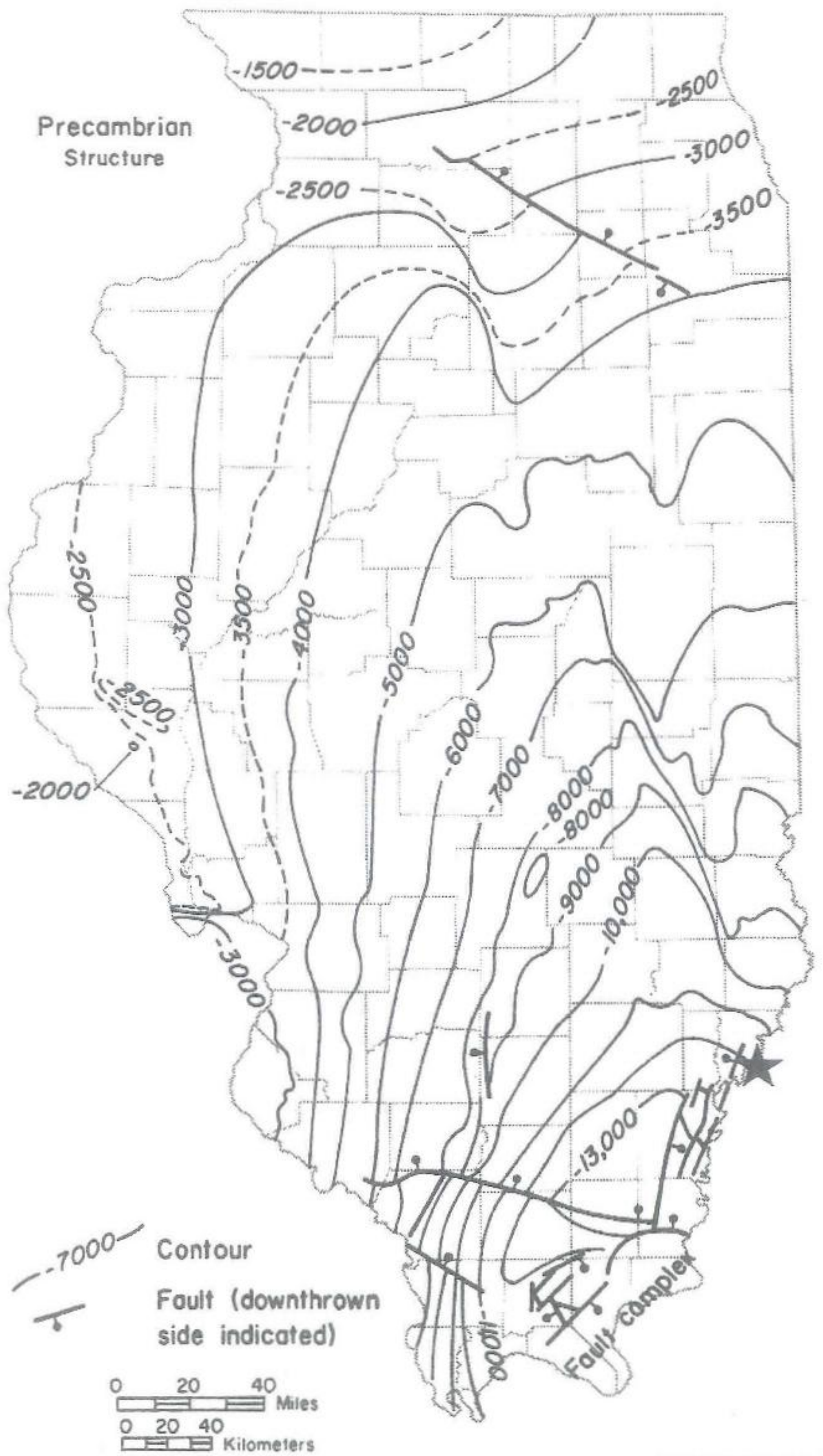
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE DEPTH OF THE PRECAMBRIAN BASEMENT IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–5

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE DEPTH OF THE PRECAMBRIAN BASEMENT IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975

LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–6

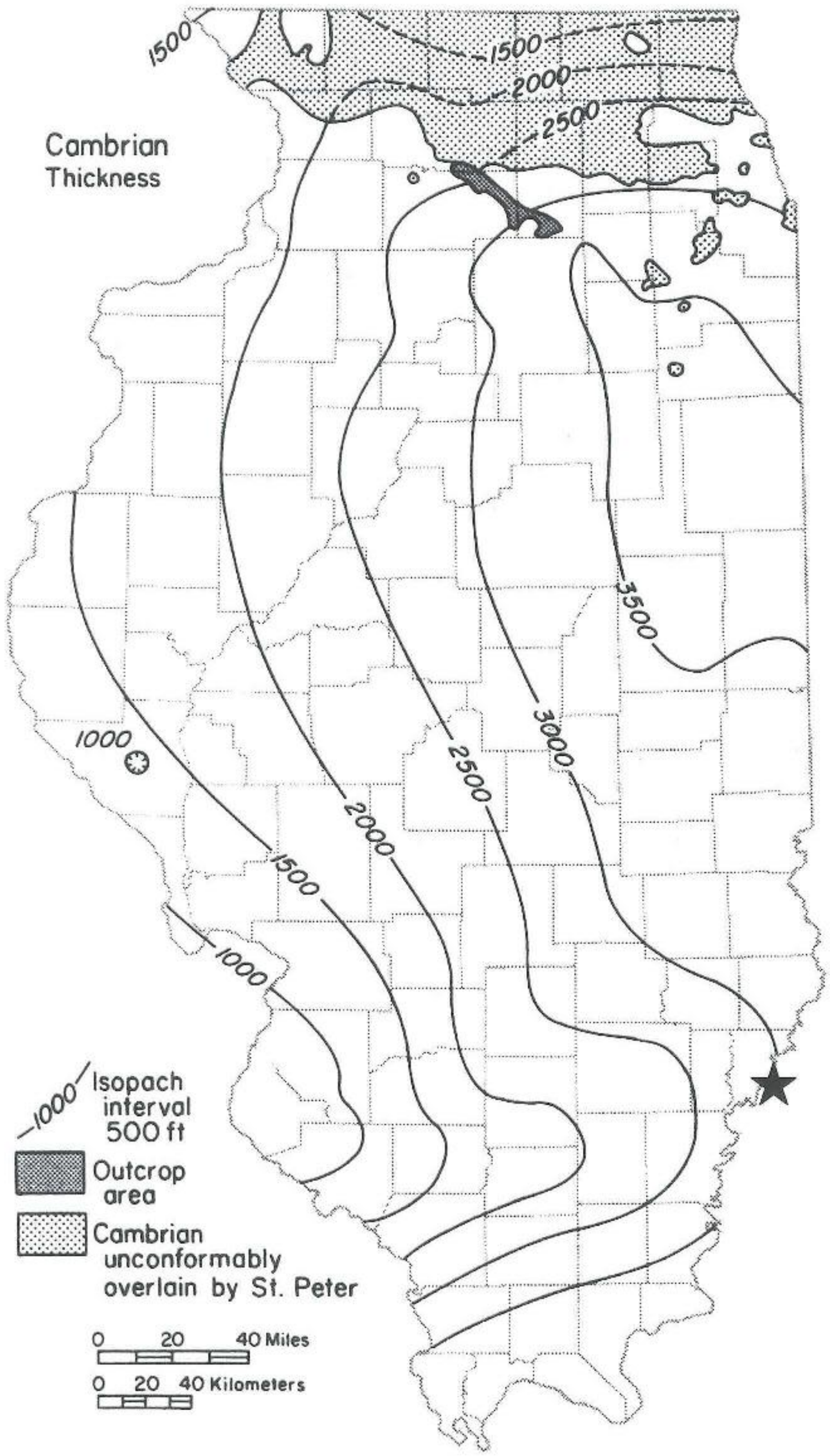
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE CAMBRIAN SYSTEM IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND PATTON, 1985



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-7

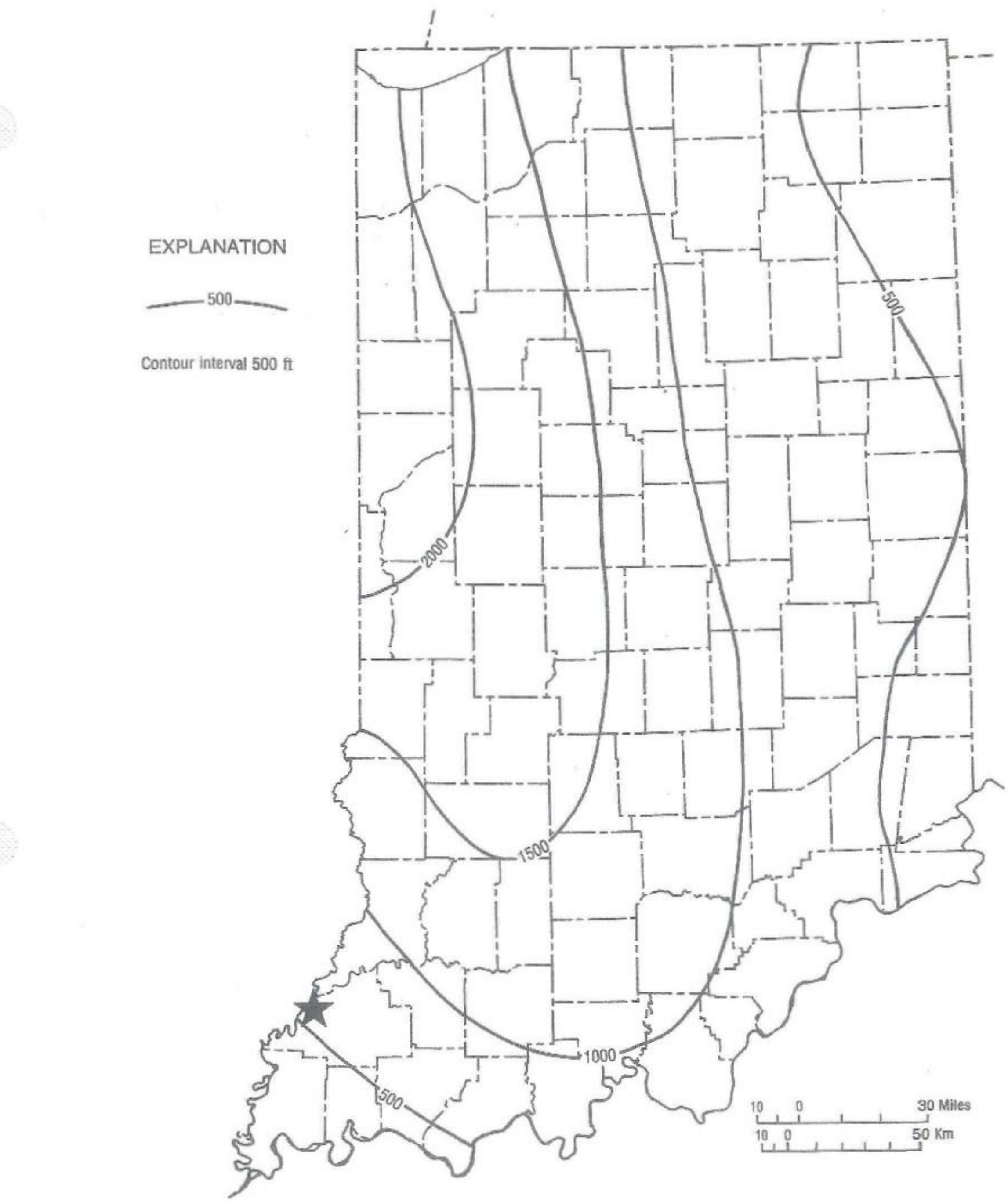
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE CAMBRIAN SYSTEM IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-8

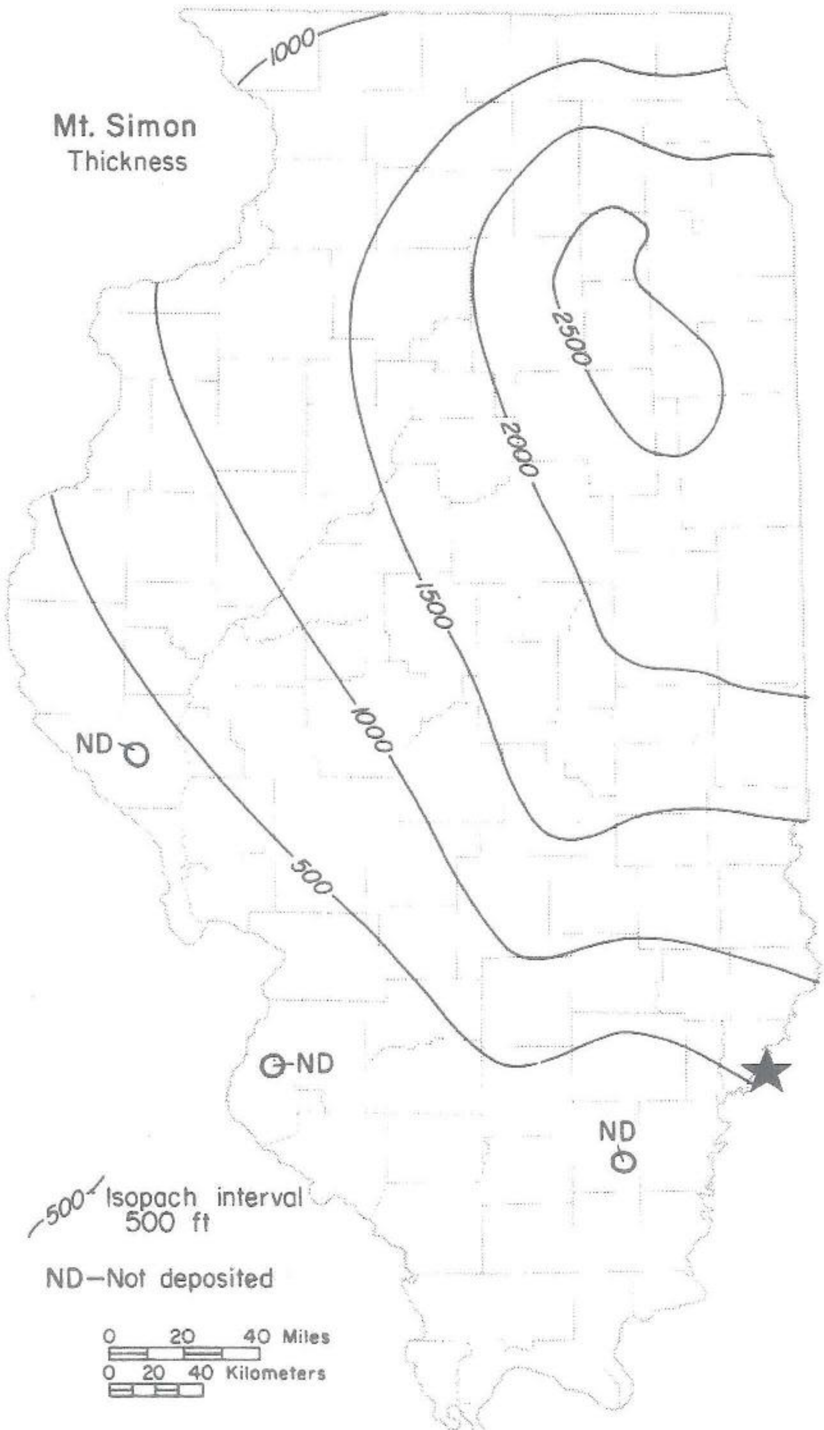
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE MT. SIMON SANDSTONE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

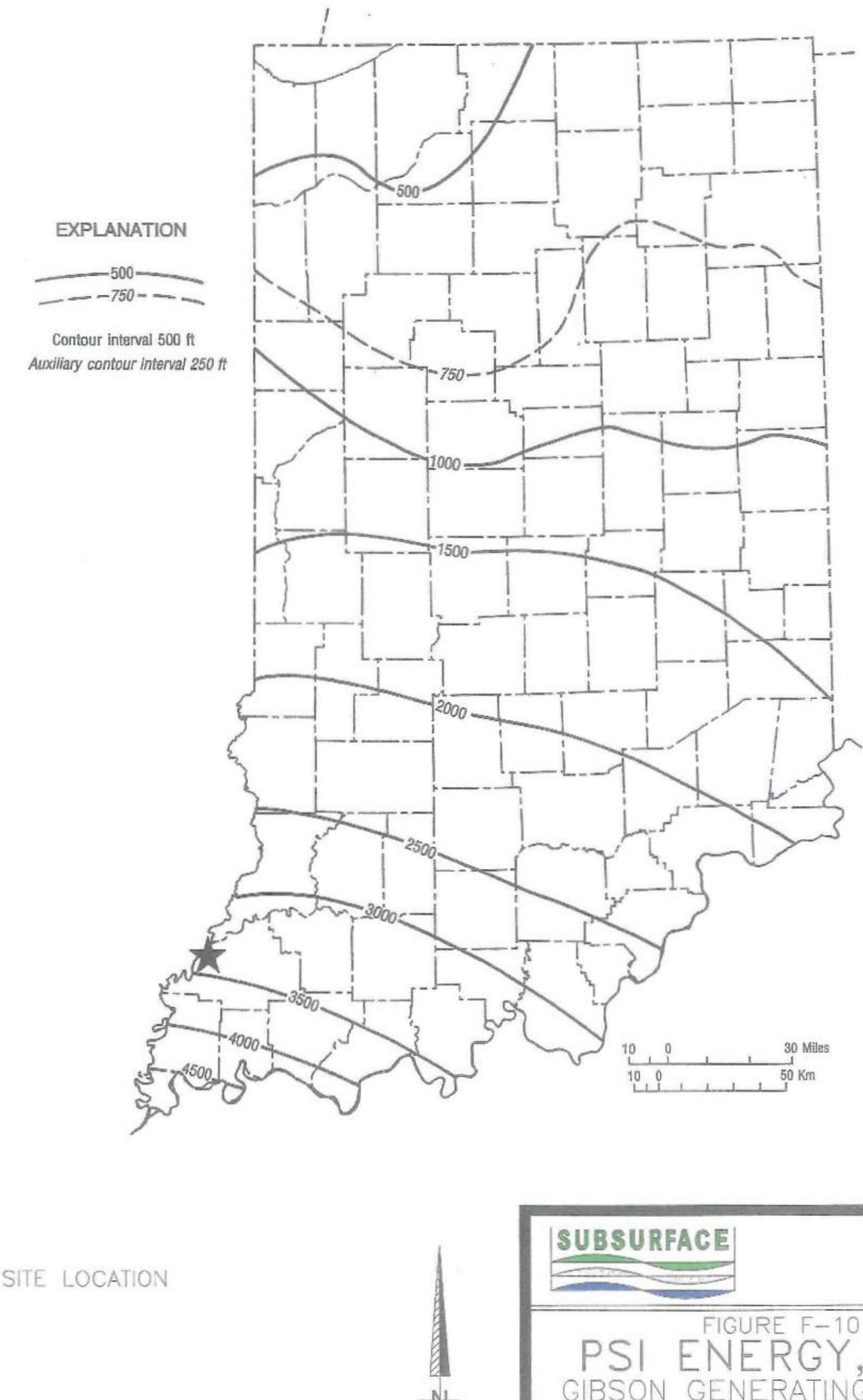
SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–9
PSI ENERGY, INC.
GIBSON GENERATING STATION
MAP SHOWING THE THICKNESS OF THE MT. SIMON SANDSTONE IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–10

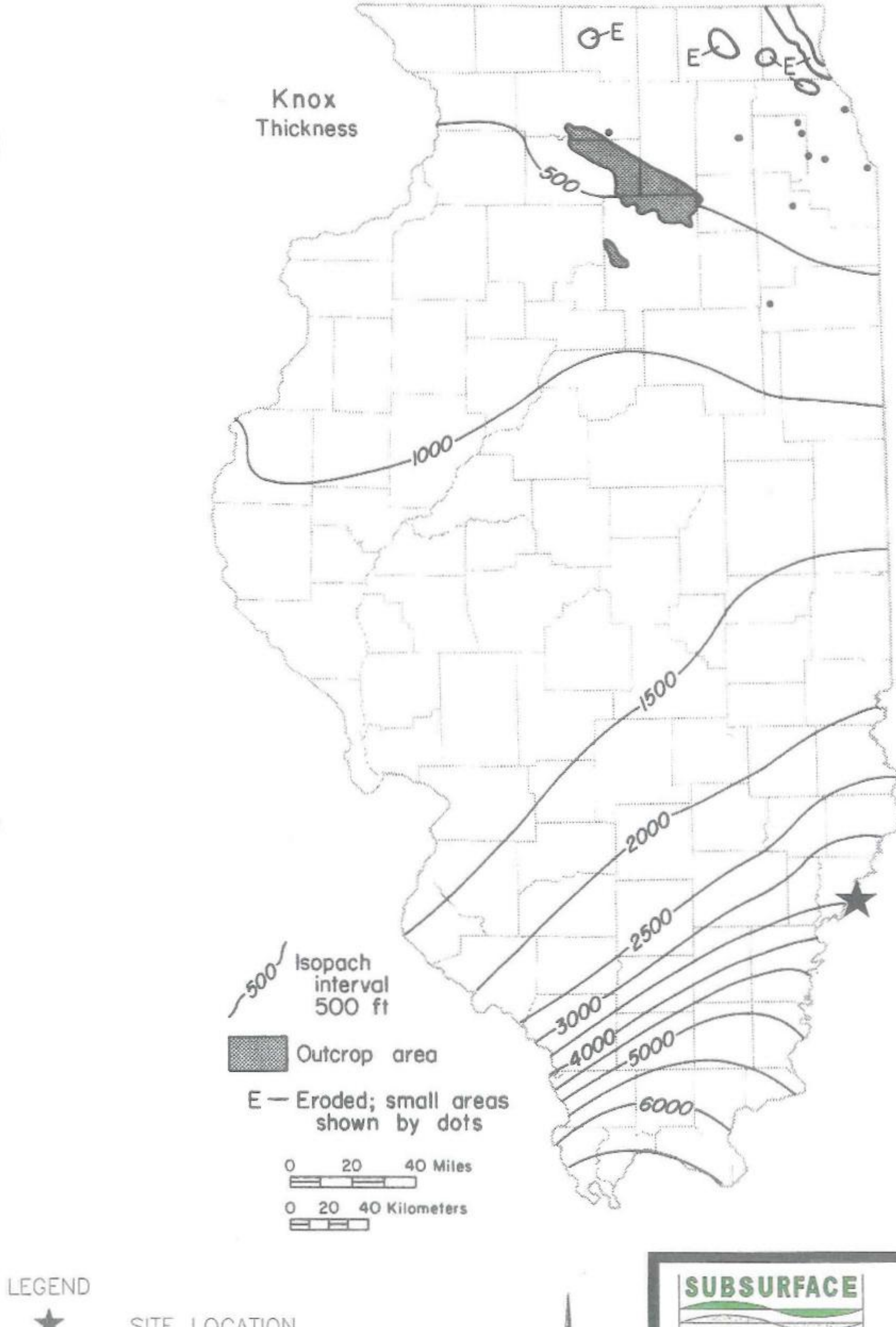
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE KNOX SUPERGROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–11

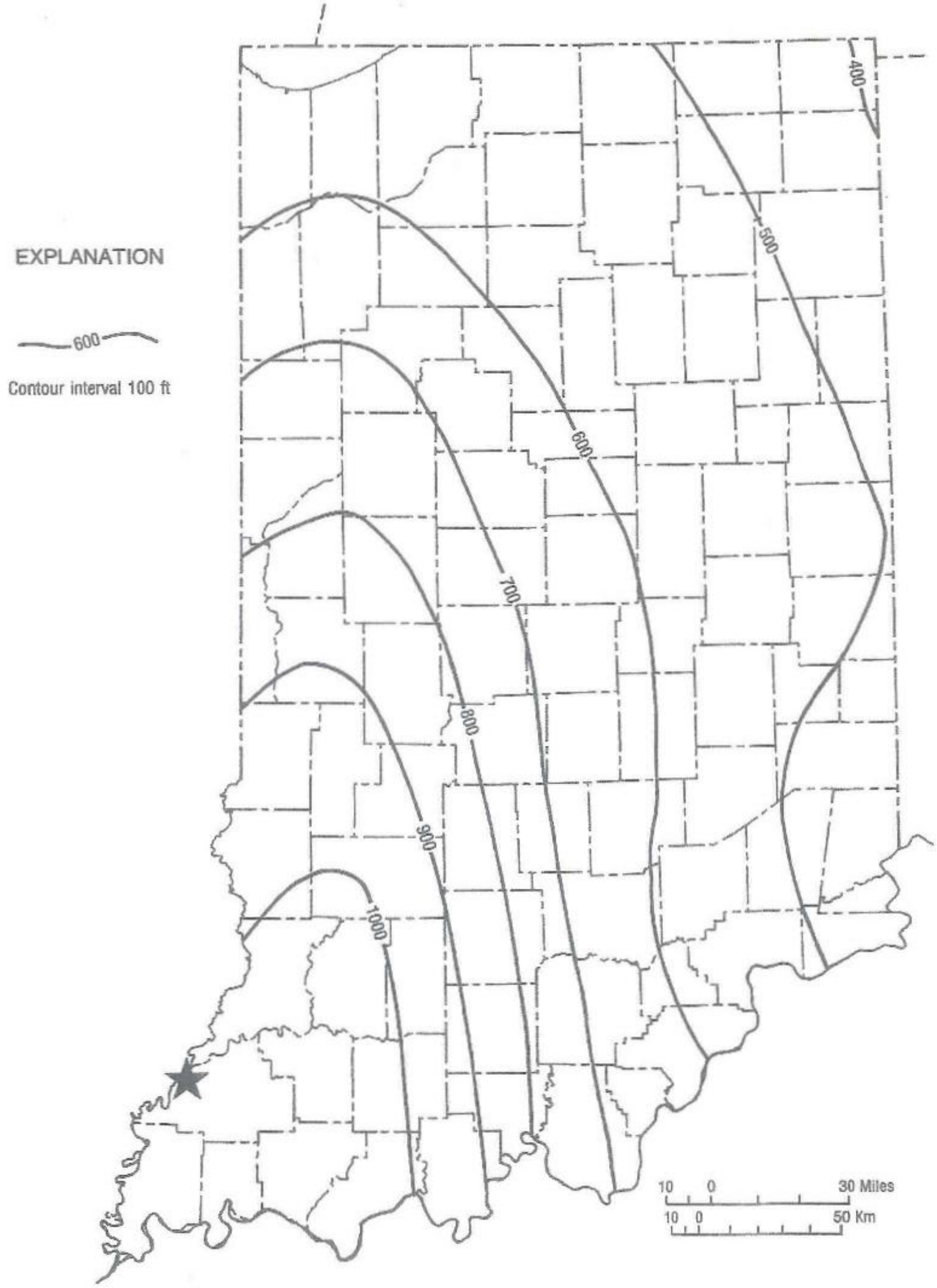
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE KNOX DOLOMITE MEGAGROUP IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND
★ SITE LOCATION

N

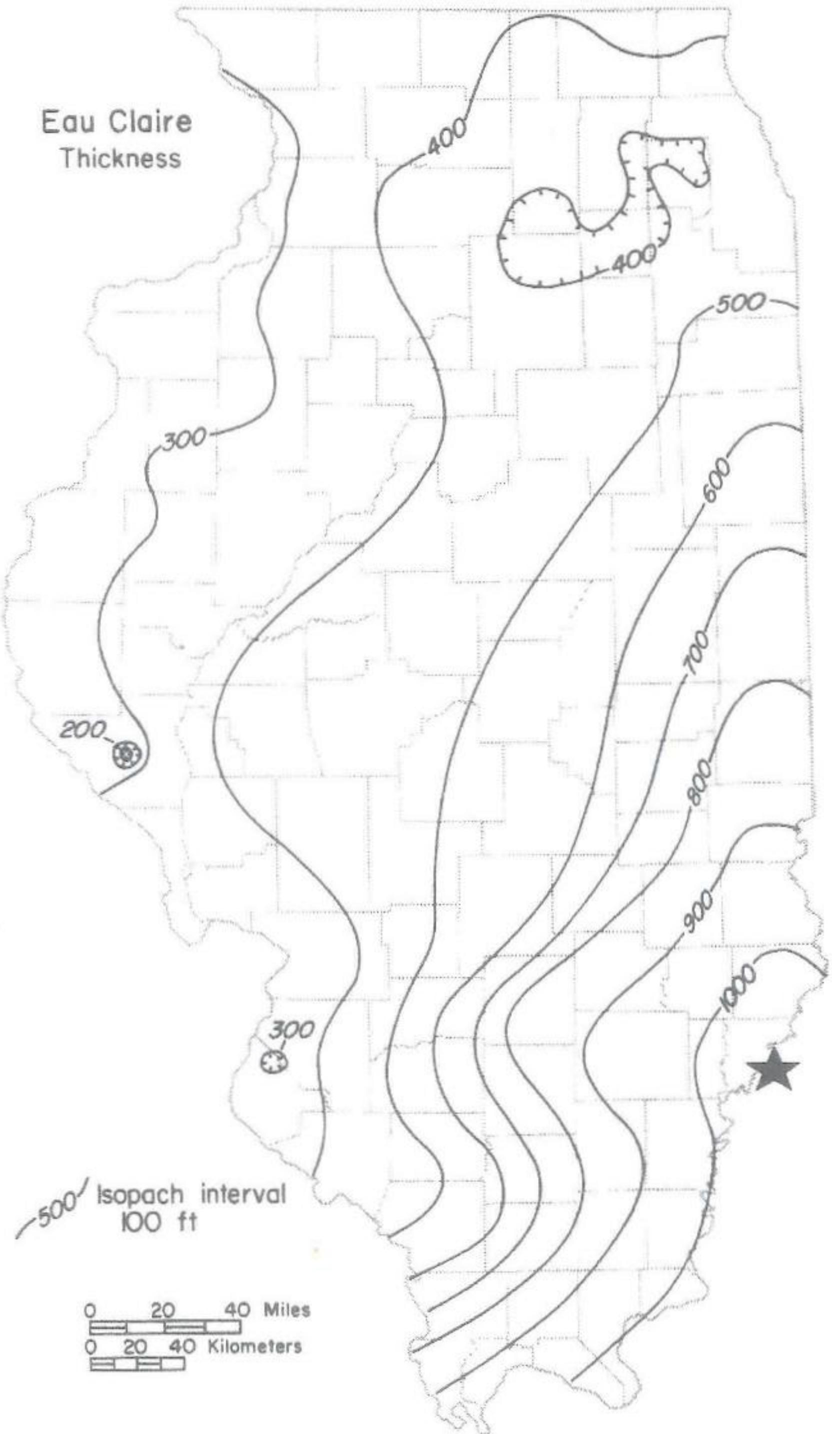
SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-12
PSI ENERGY, INC.
GIBSON GENERATING STATION
MAP SHOWING THE THICKNESS OF THE EAU CLAIRE FORMATION IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-13

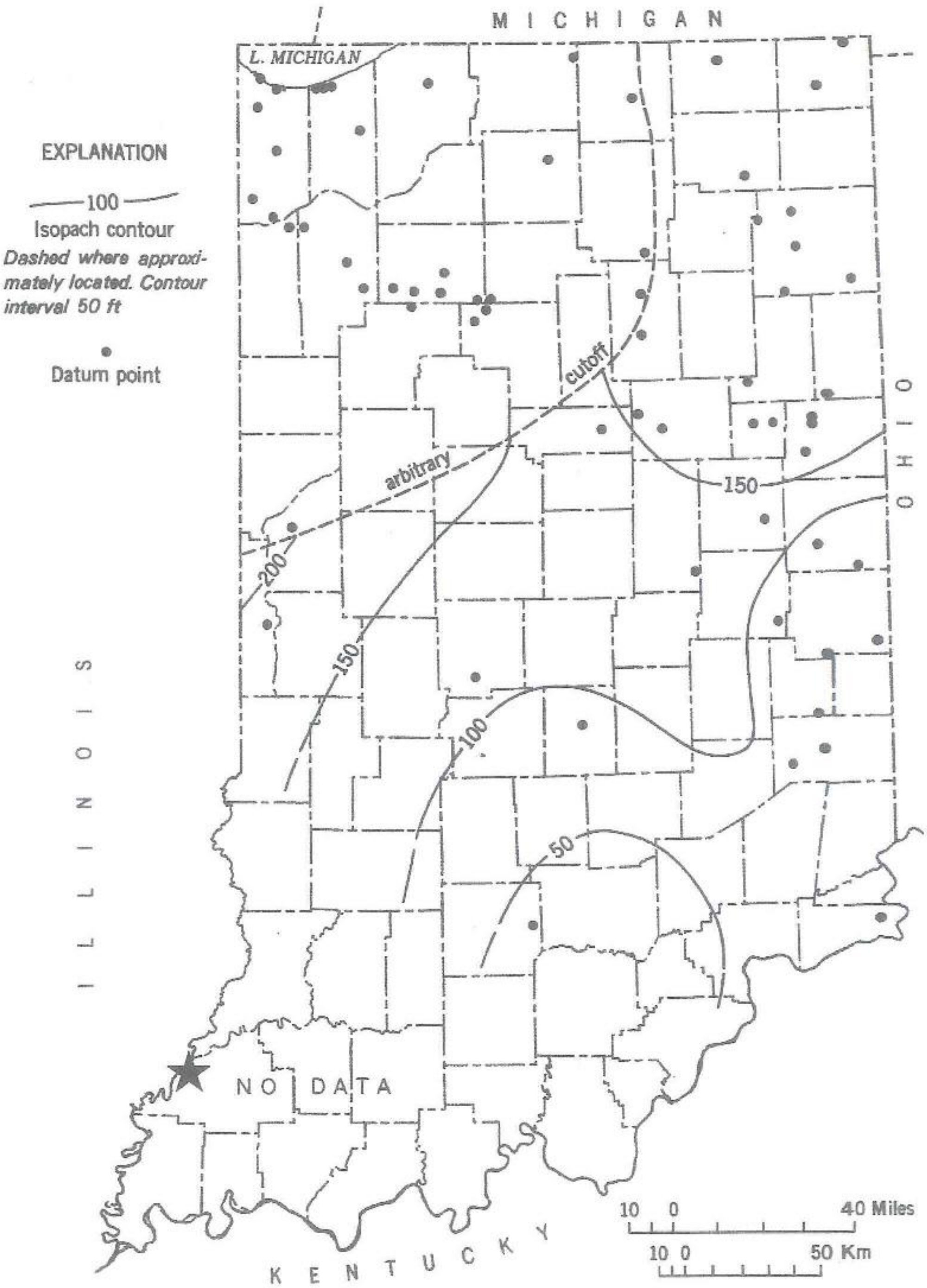
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE EAU CLAIRE FORMATION IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-14

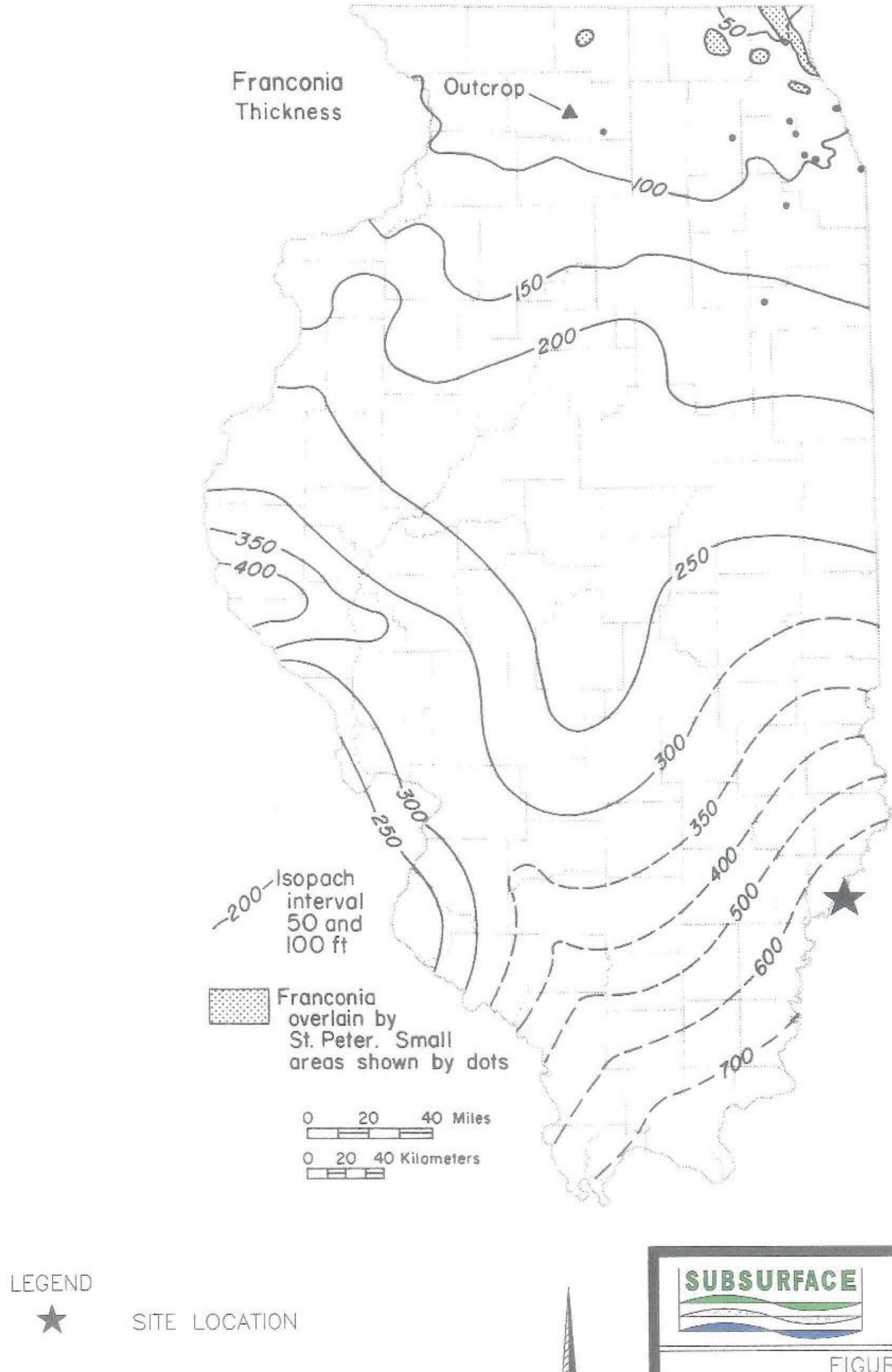
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE DAVIS FORMATION IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: BECKER, HREHA, AND DAWSON, 1978



SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-15

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE FRANCONIA FORMATION IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975

LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-16

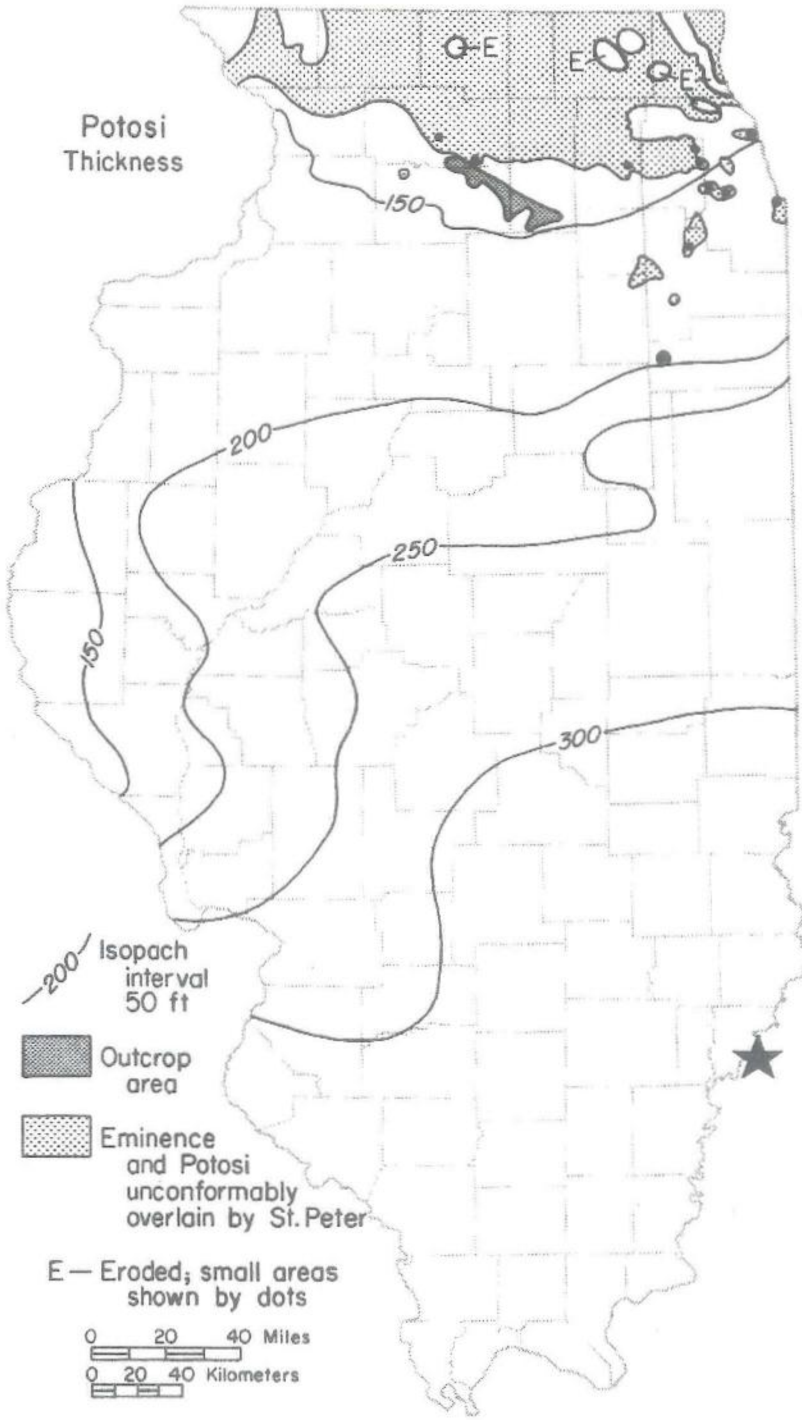
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE POTOSI DOLOMITE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND PATTON, 1985



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-17

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE POTOSI DOLOMITE IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975

LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–18

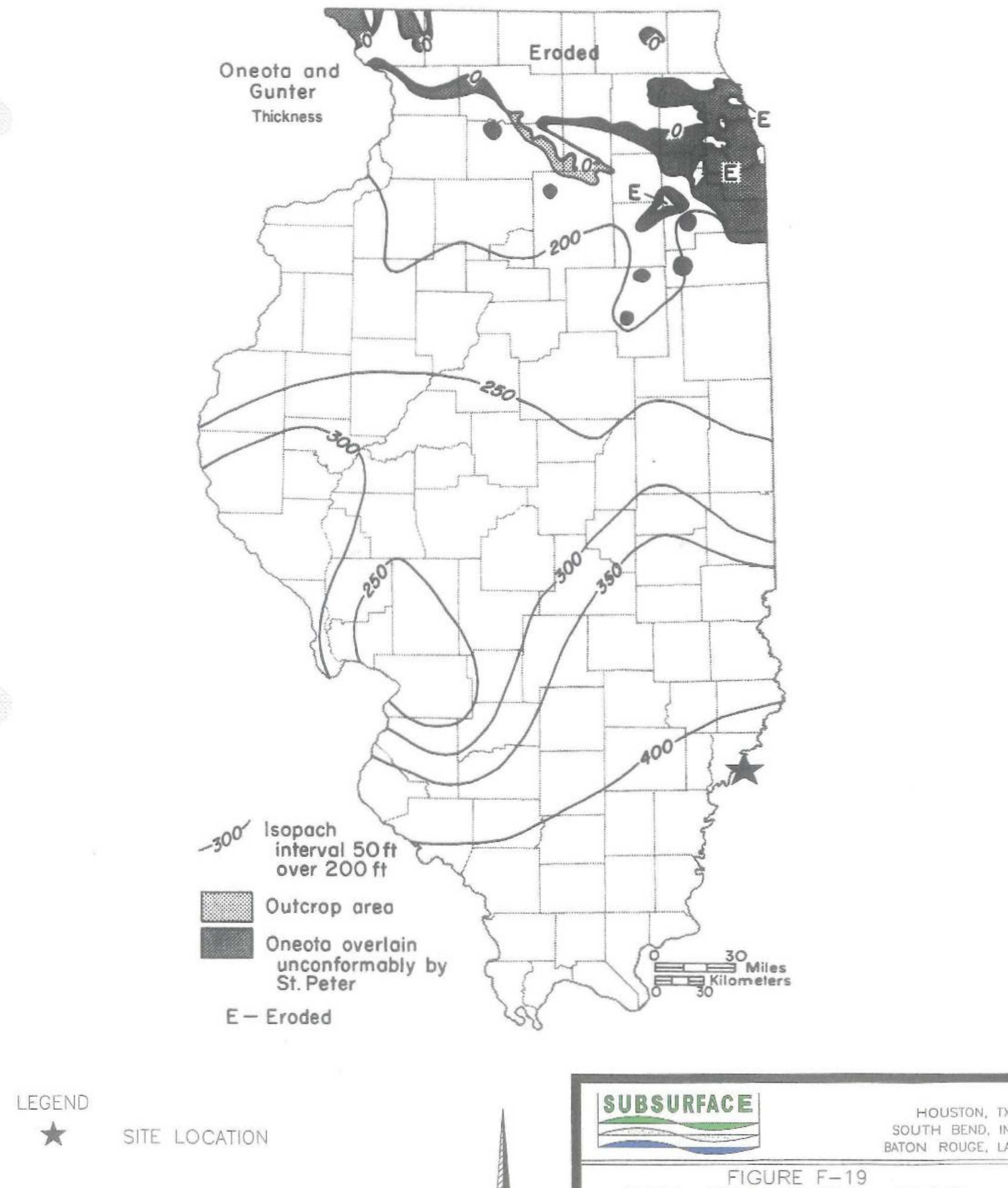
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE ONEOTA DOLOMITE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND PATTON, 1985



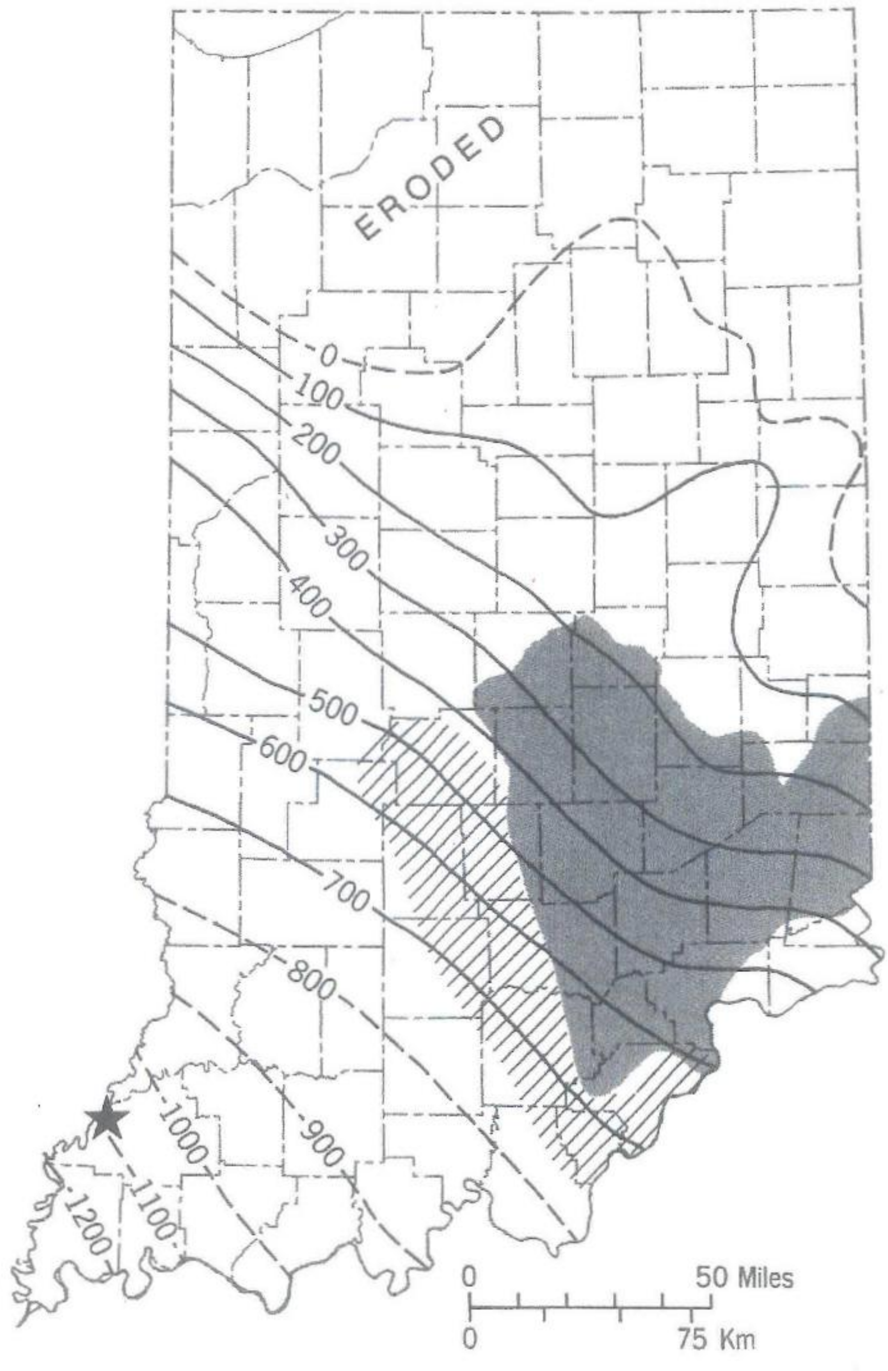
SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-19
PSI ENERGY, INC.
GIBSON GENERATING STATION
MAP SHOWING THE THICKNESS OF THE ONEOTA DOLOMITE IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–20

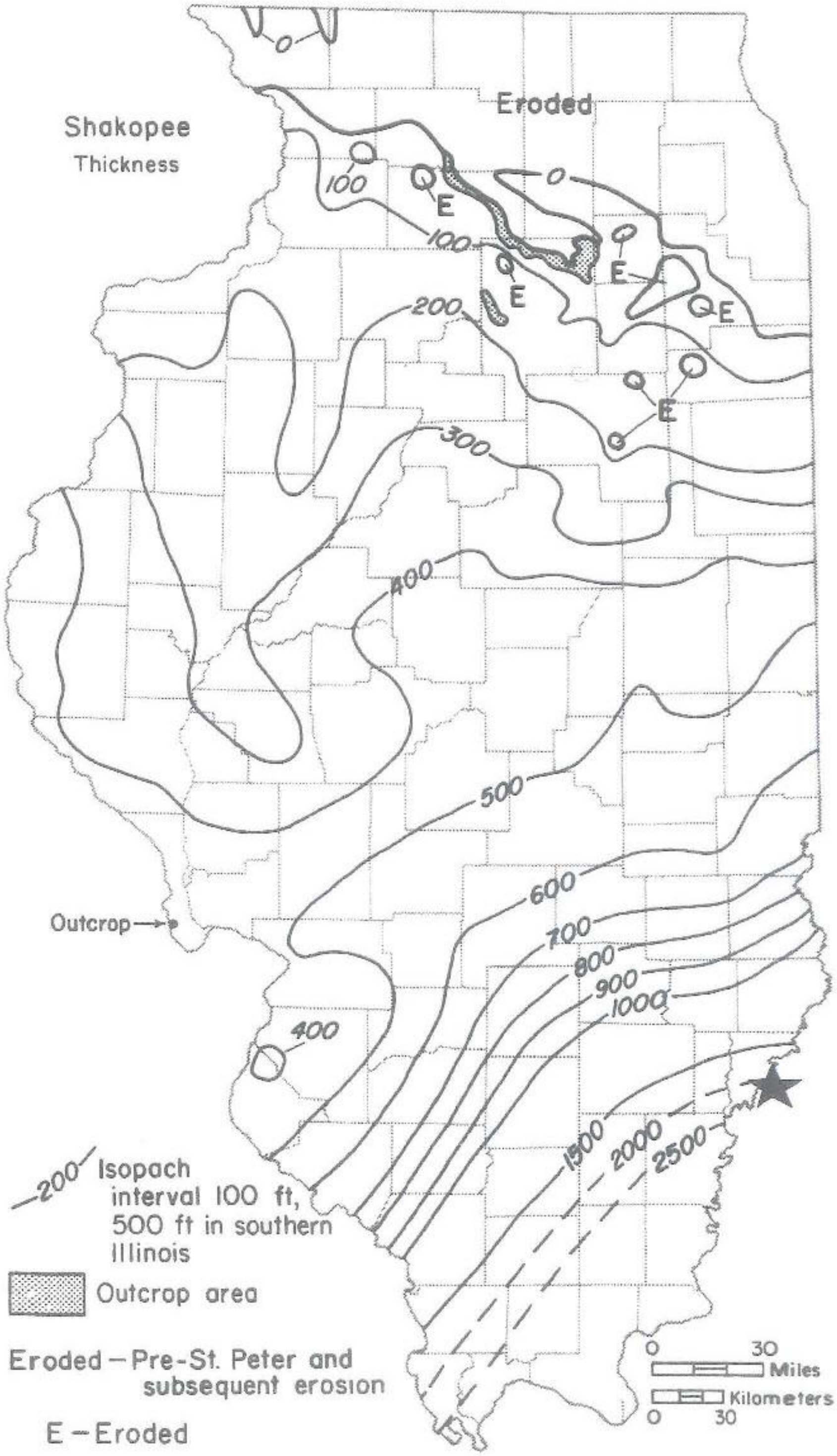
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE SHAKOPEE DOLOMITE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 6OD5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND PATTON, 1985



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-21

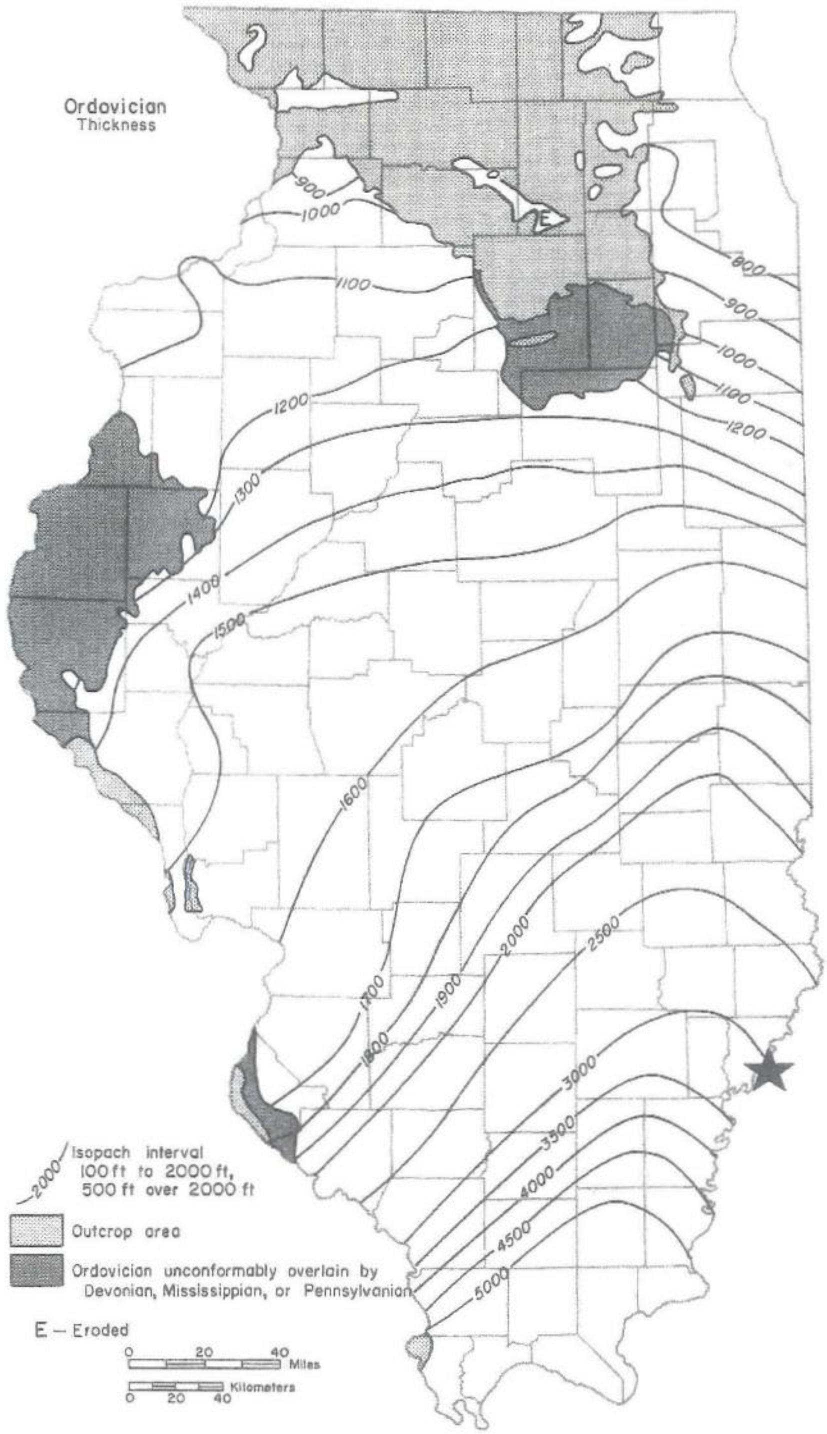
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE SHAKOPEE DOLOMITE IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–22

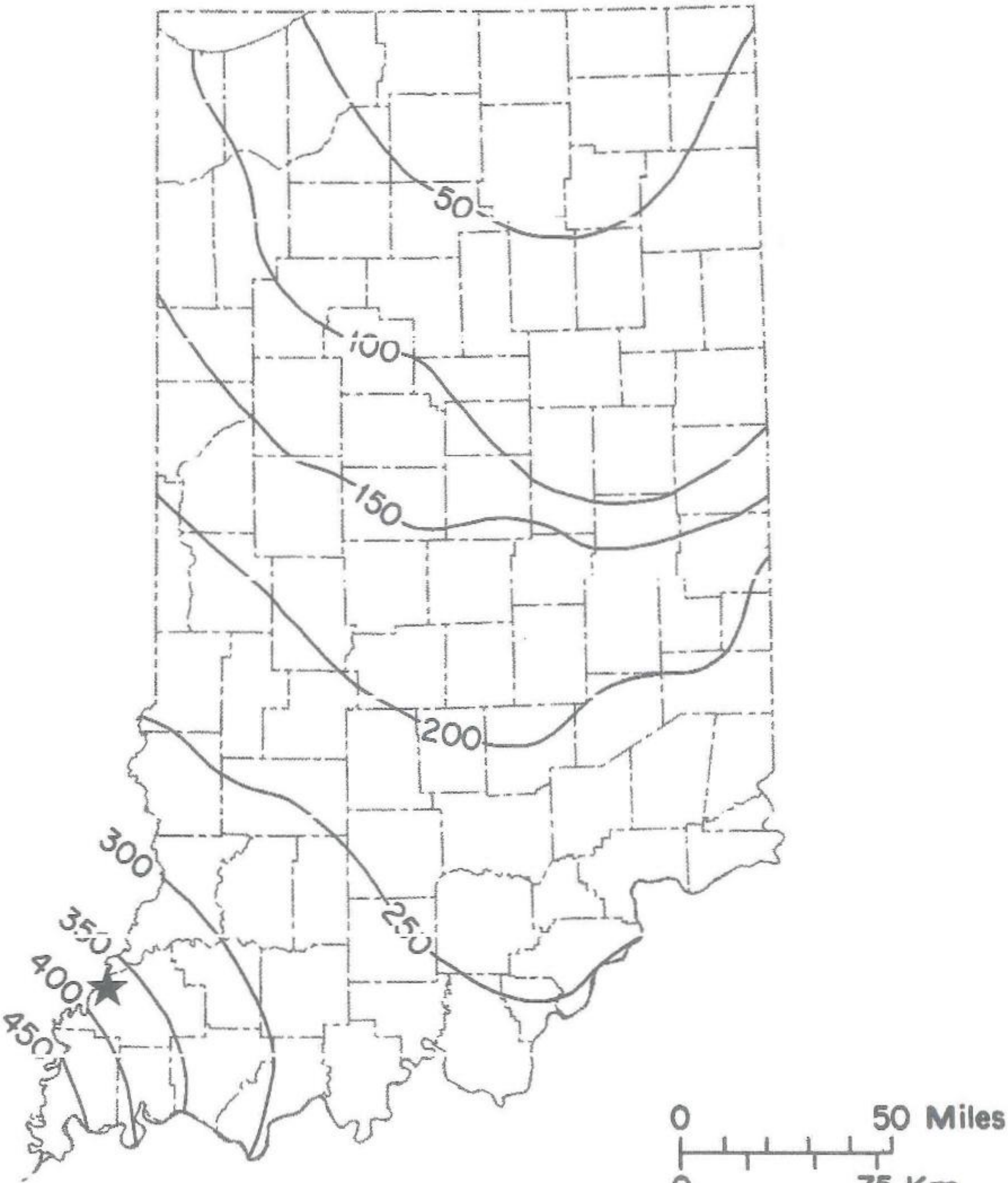
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE ORDOVICIAN SYSTEM IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-23

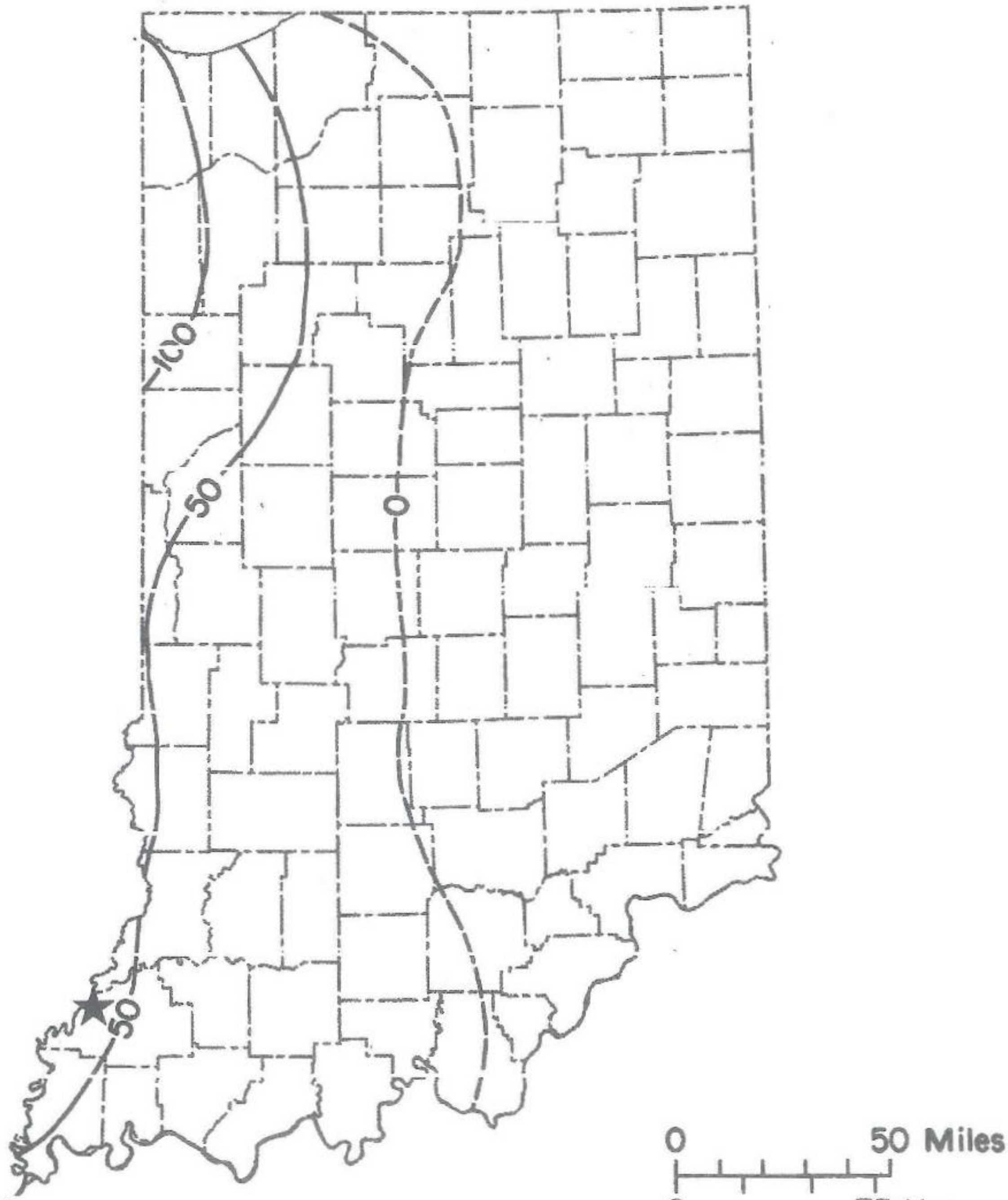
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE ANCELL GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE, ABDULKAREEM, AND PATTON, 1982



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-24

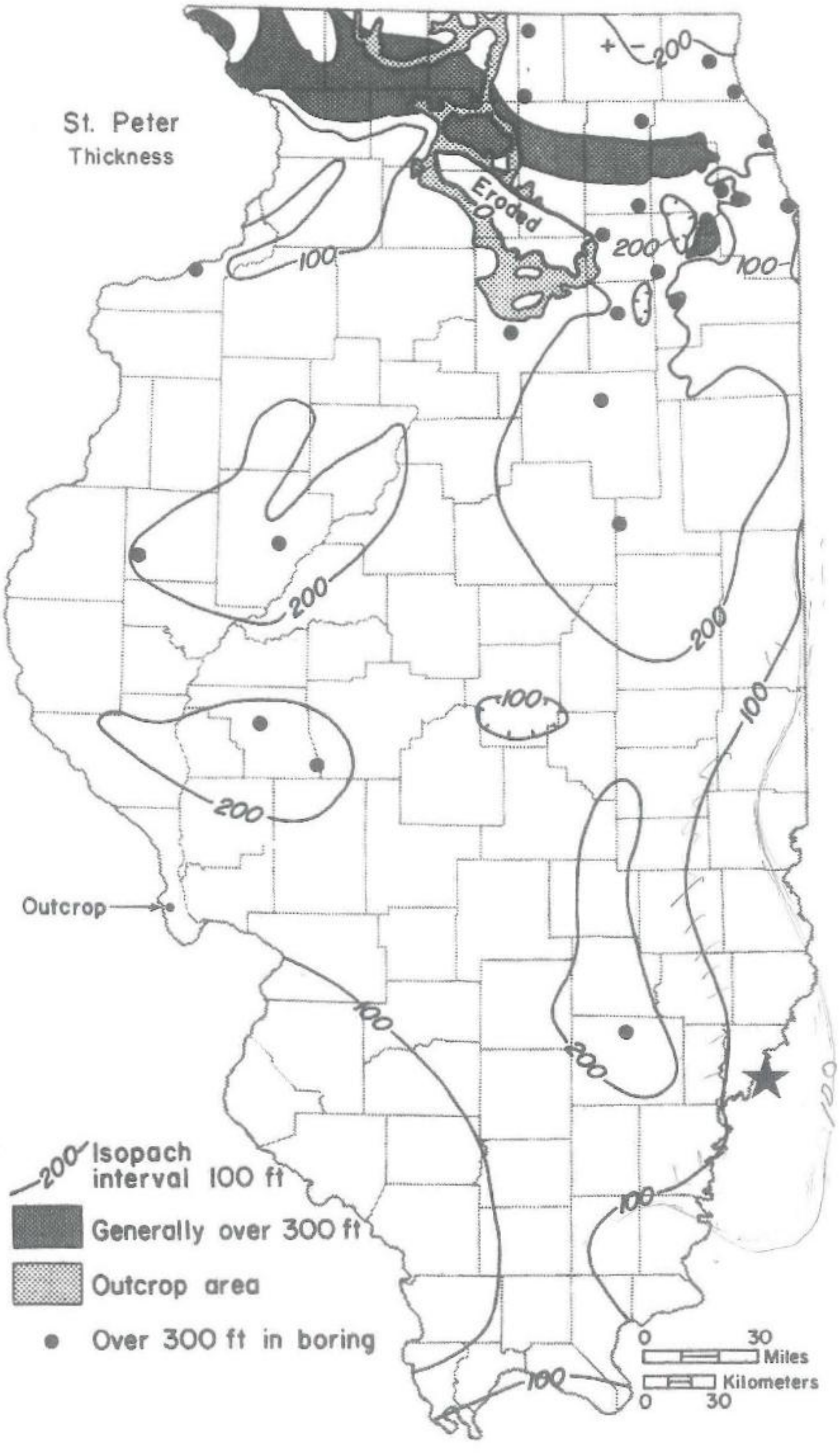
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE ST. PETER SANDSTONE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE, ABDULKAREEM, AND PATTON, 1982



LEGEND

★ SITE LOCATION

N

SOURCE: WILLMAN, et al, 1975

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-25

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE ST. PETER SANDSTONE IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 6005675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-26

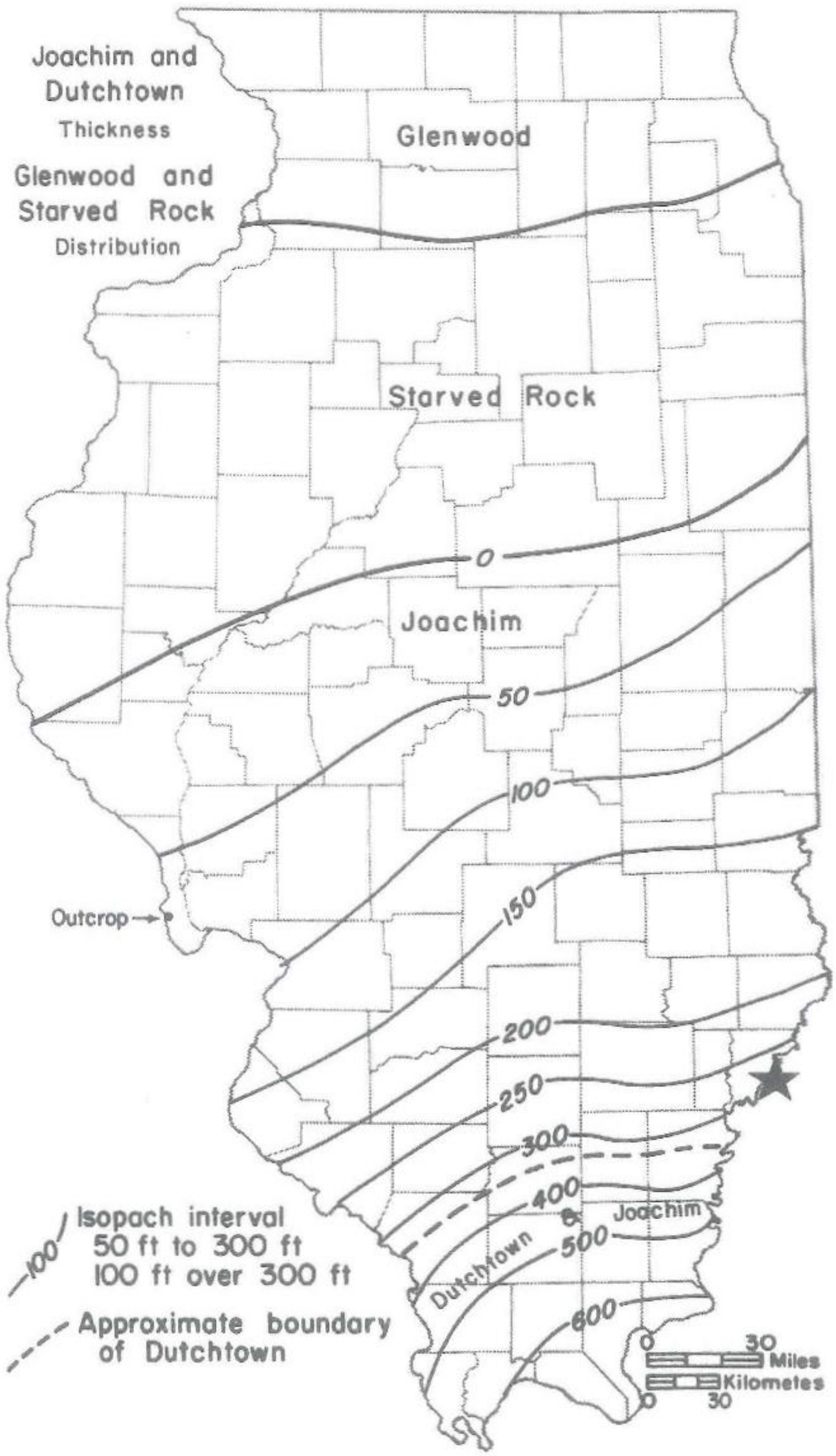
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE DUTCHTOWN FORMATION IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE, ABDULKAREEM, AND PATTON, 1982



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-27

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE DUTCHTOWN AND JOACHIM FORMATIONS IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975

LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-28

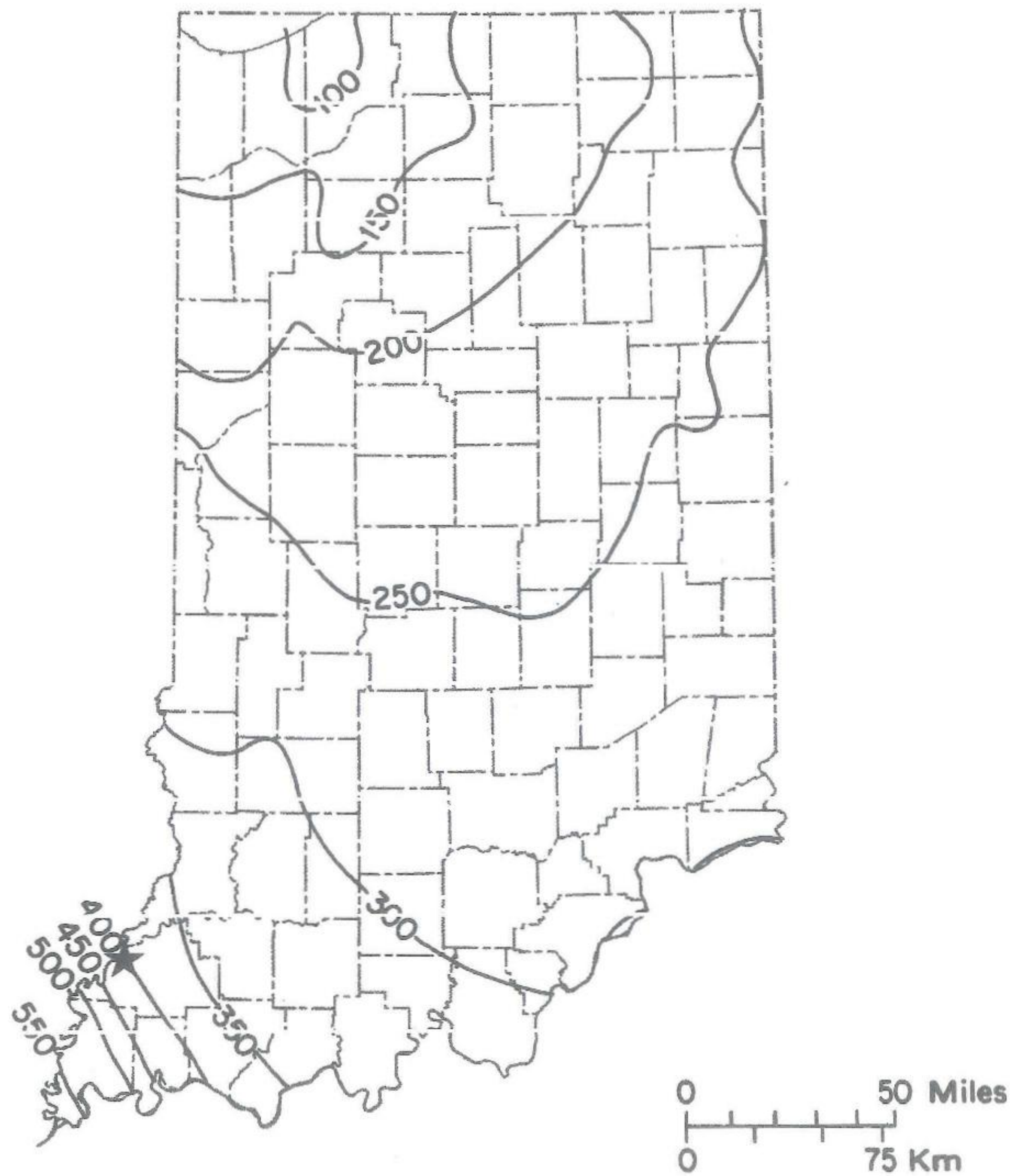
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE JAOCHIM FORMATION IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE, ABDULKAREEM, AND PATTON, 1982



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-29

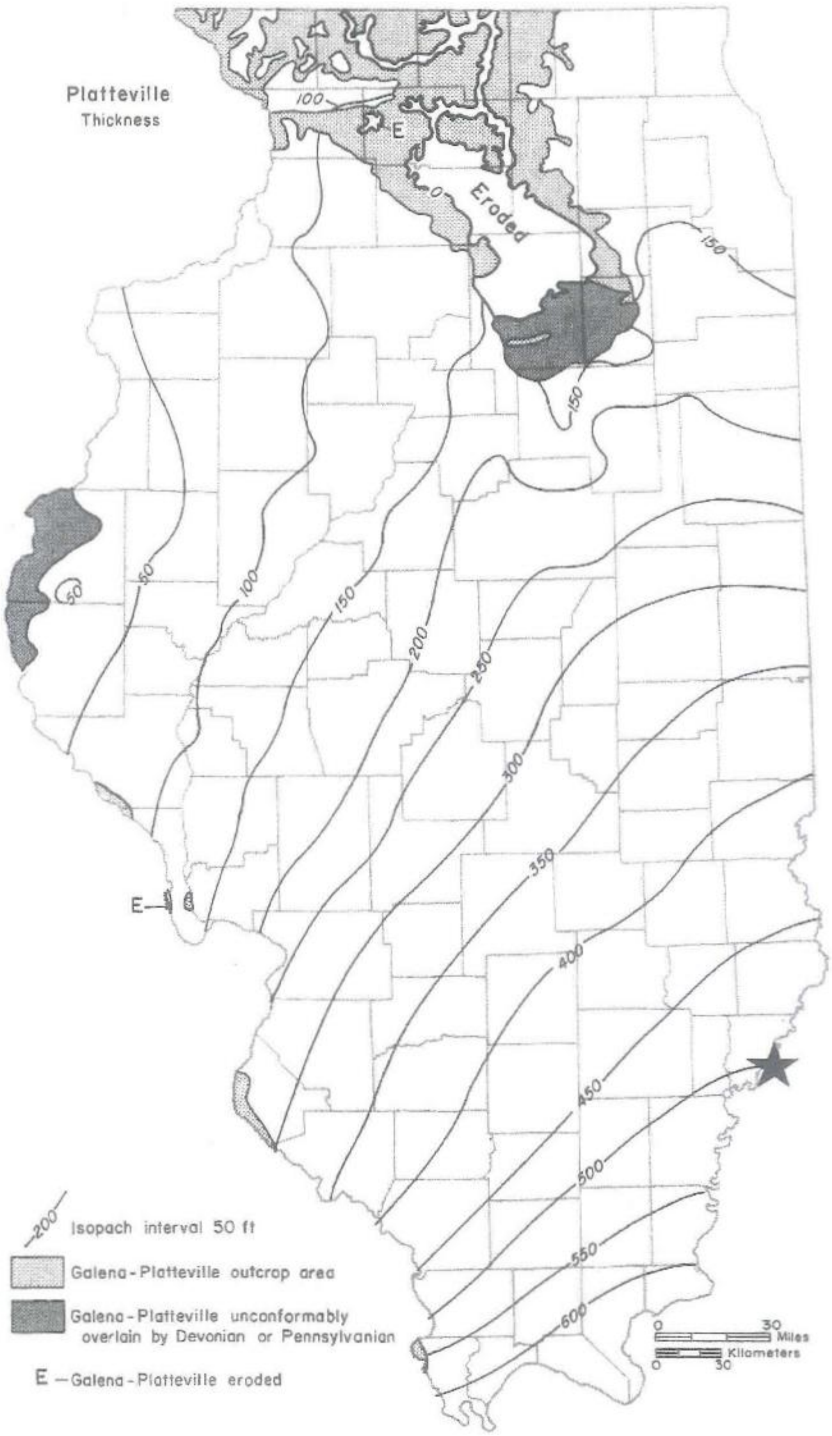
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE BLACK RIVER GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE, ABDULKAREEM, AND PATTON, 1982



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-30

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE PLATTEVILLE GROUP IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975

LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-31

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE PECATONICA FORMATION IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 6OD5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE, ABDULKAREEM, AND PATTON, 1982

LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-32

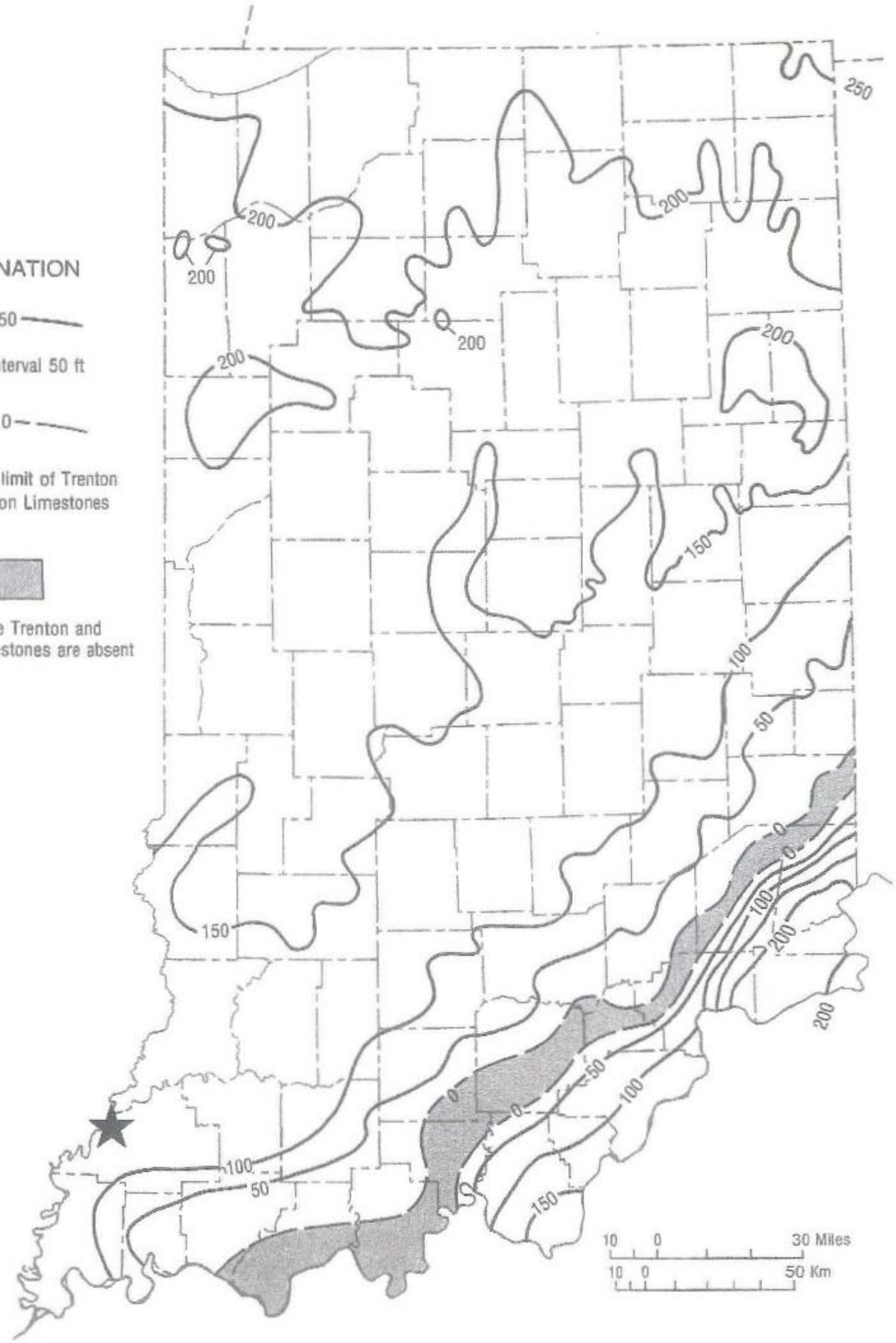
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF
THE PLATTIN FORMATION IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE, ABDULKAREEM, AND PATTON, 1982



EXPLANATION

150

Contour interval 50 ft

0

Approximate limit of Trenton and Lexington Limestones

Area where Trenton and Lexington Limestones are absent

LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-33

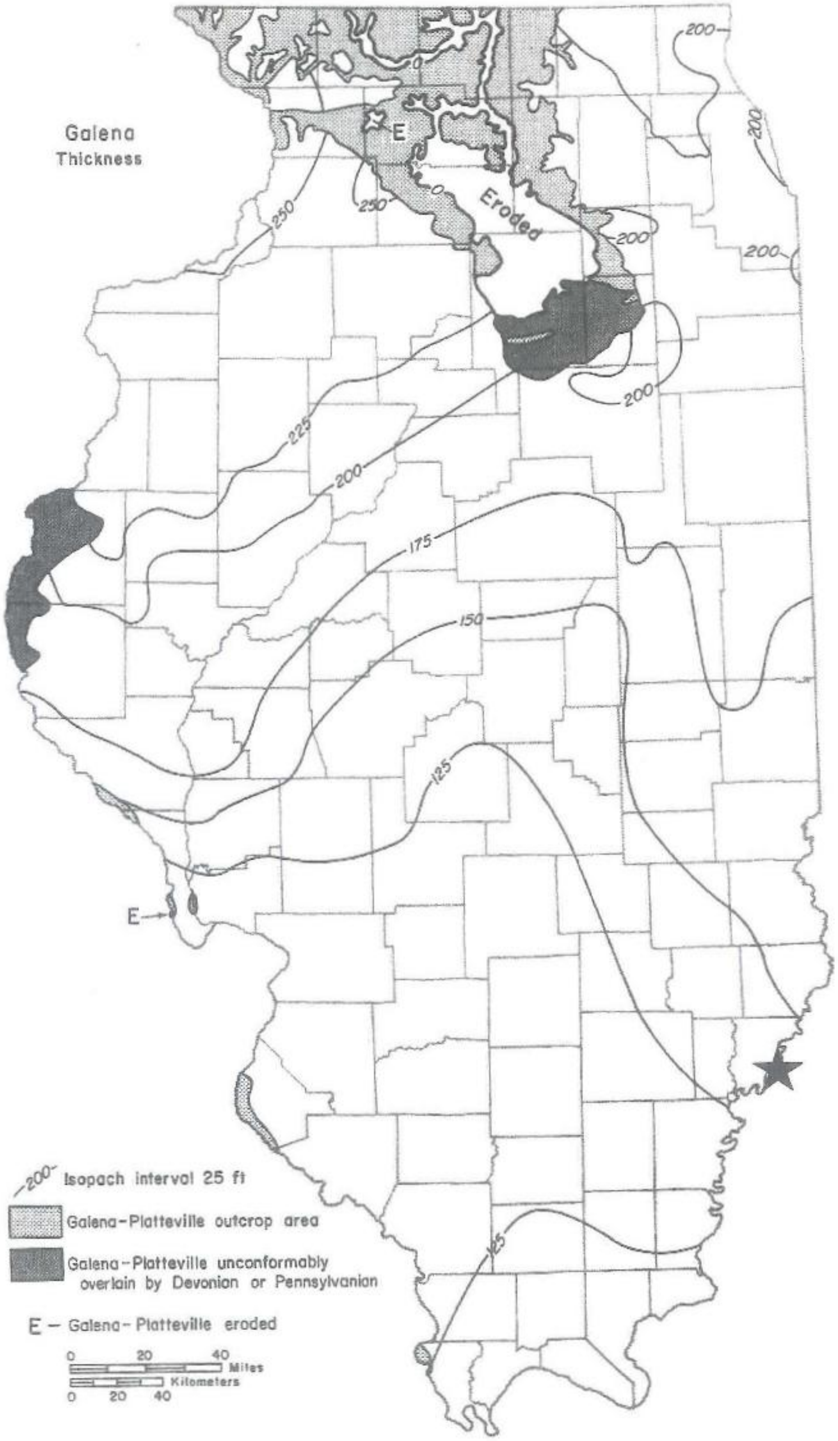
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE TRENTON AND LEXINGTON LIMESTONE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–34

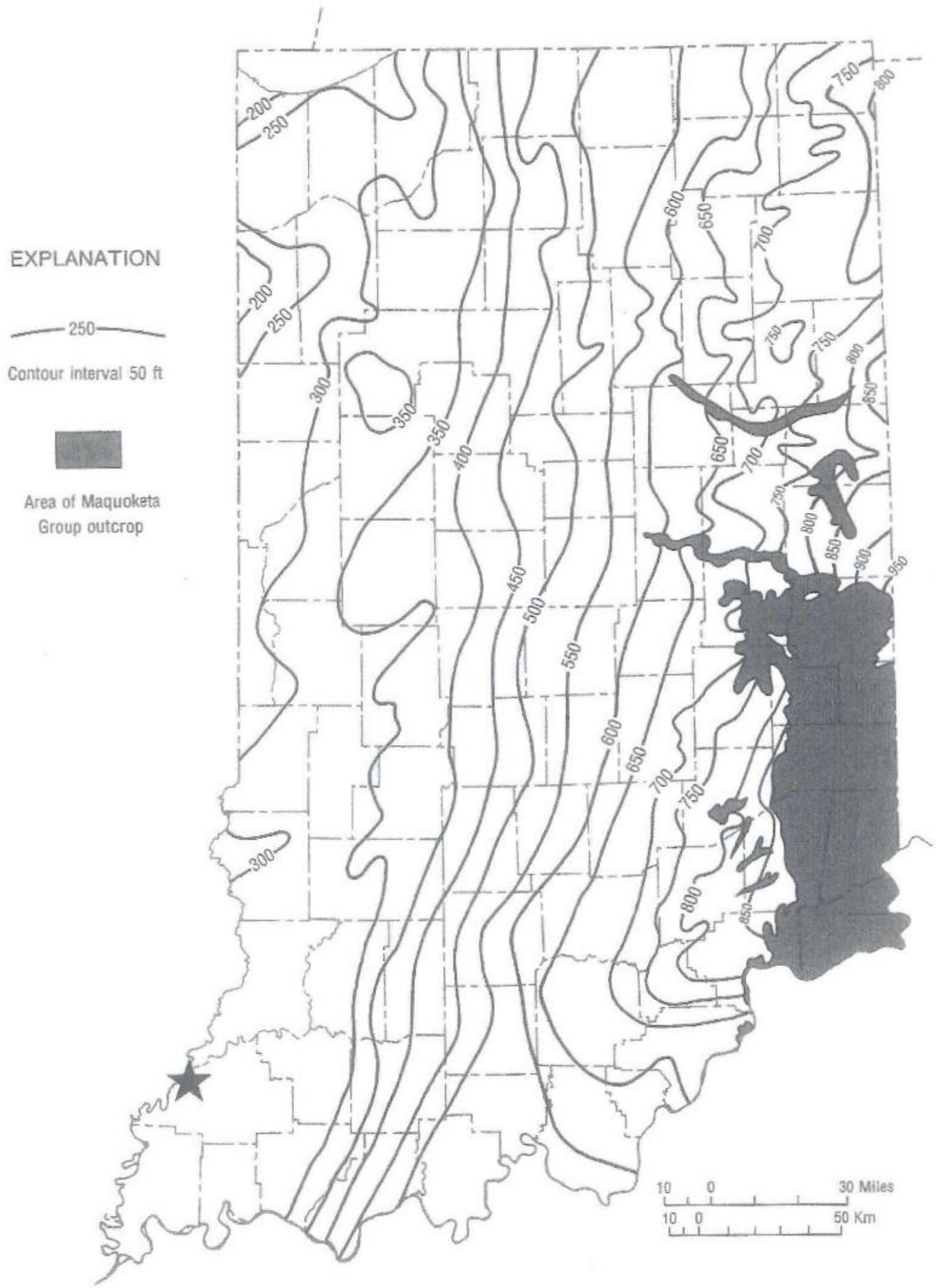
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE GALENA GROUP IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-35

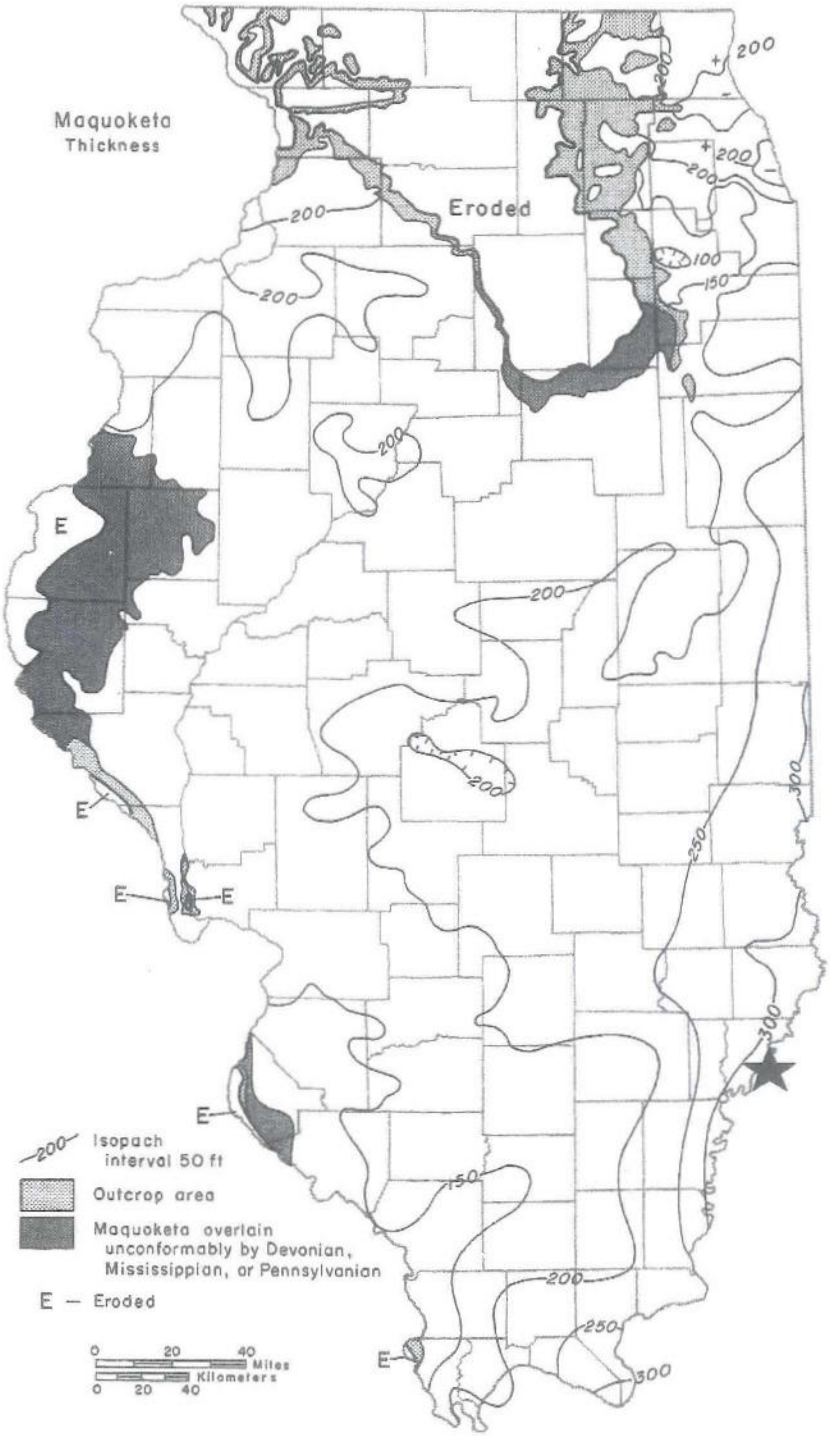
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE MAQUOKETA GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–36

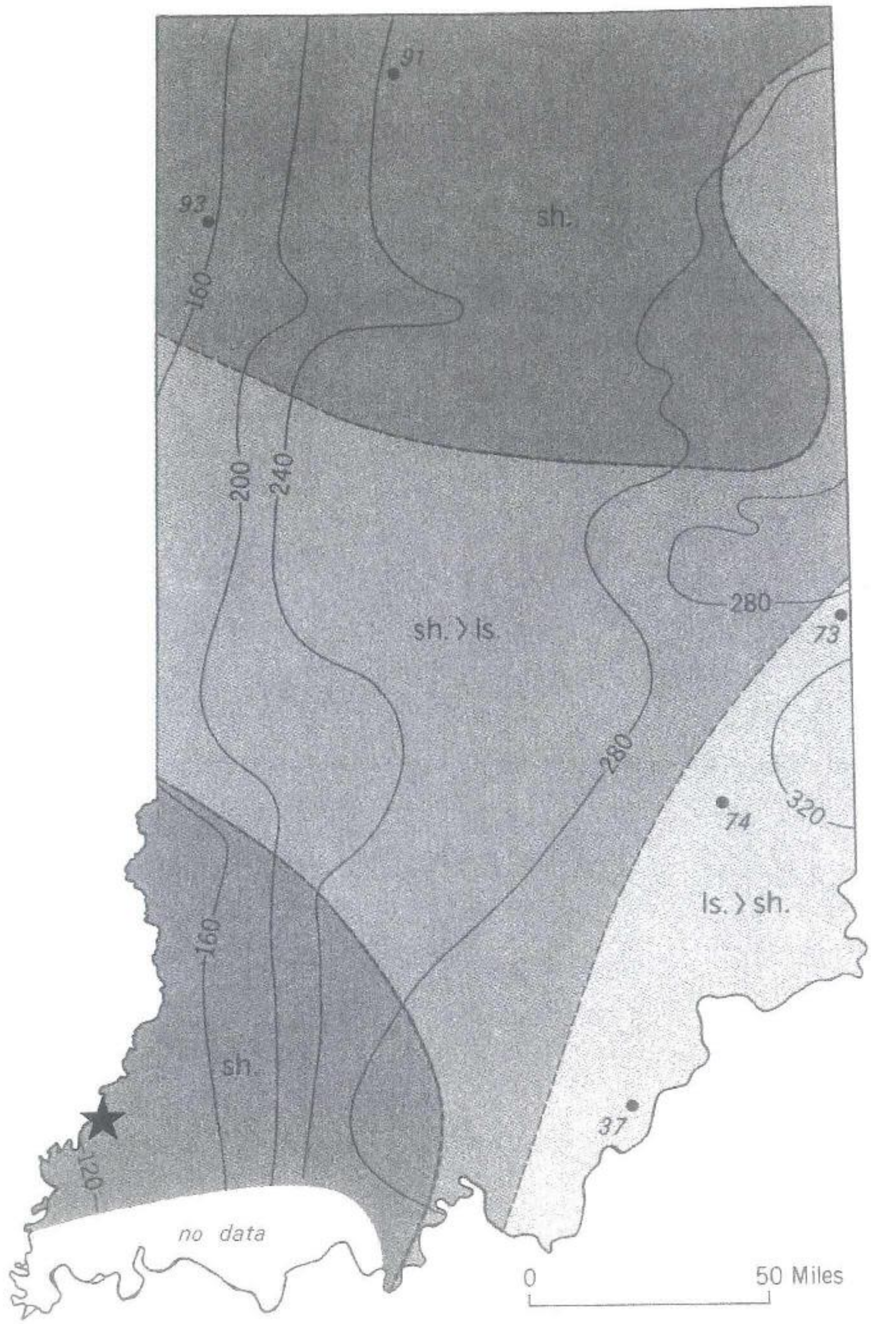
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE MAQUOKETA GROUP IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

SOURCE: GRAY, 1972

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

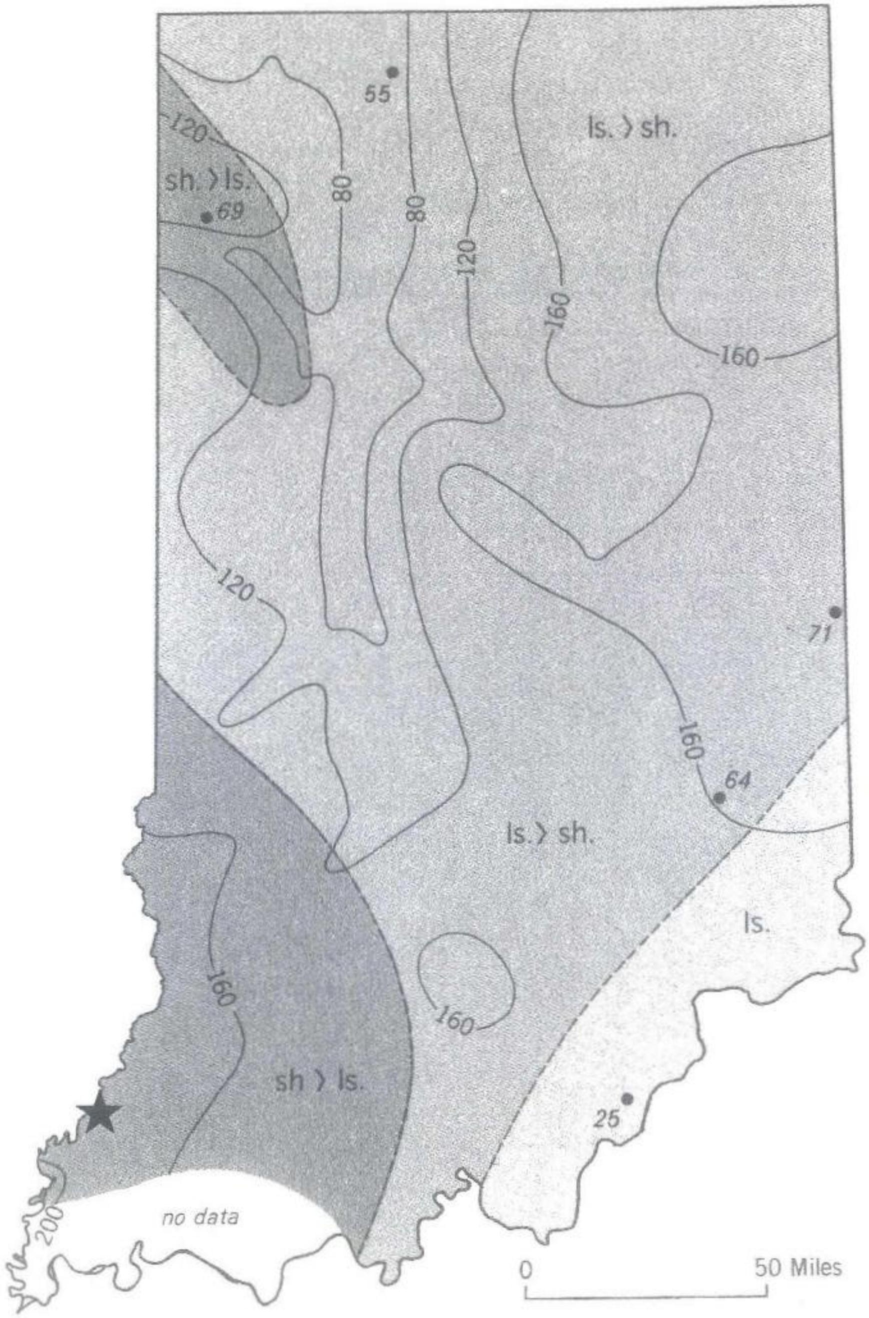
FIGURE F–37

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS AND LITHOFACIES INTERPRETATIONS OF UNIT B MAQUOKETA GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-38

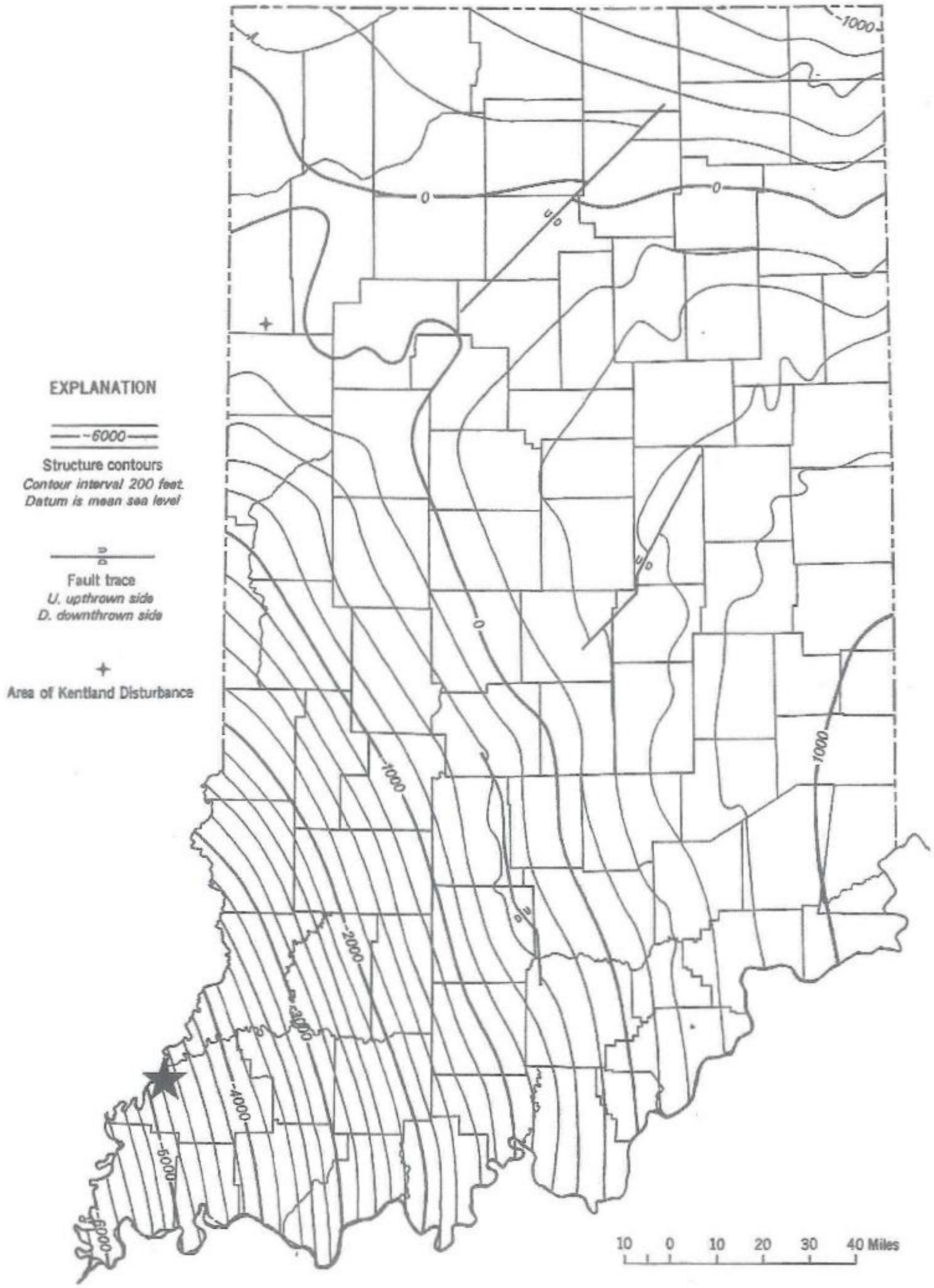
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS AND LITHOFACIES INTERPRETATIONS OF UNIT C MAQUOKETA GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: GRAY, 1972



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-39

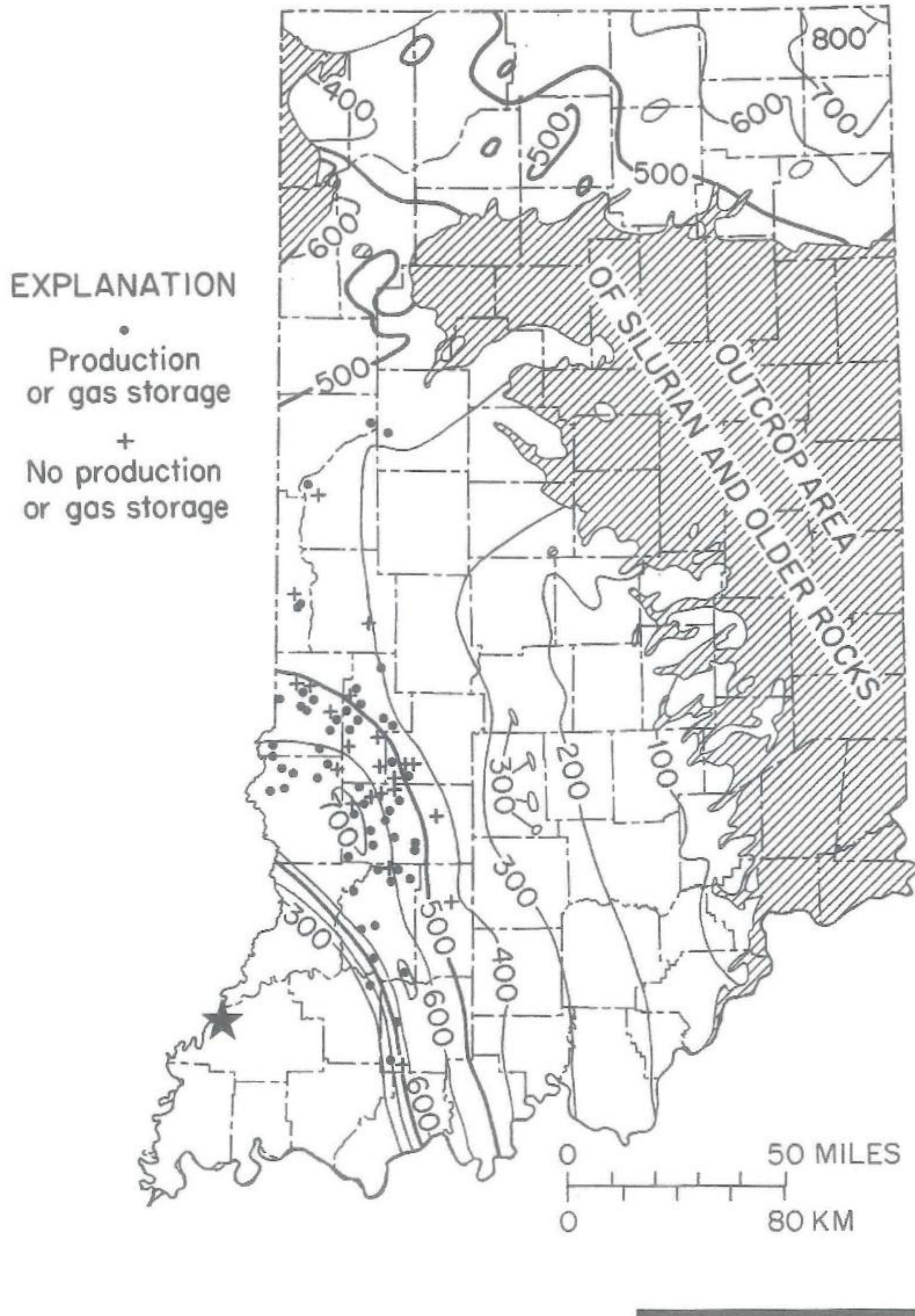
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE STRUCTURAL CONFIGURATION ON TOP OF THE MAQUOKETA GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: GRAY, 1972



LEGEND
★ SITE LOCATION

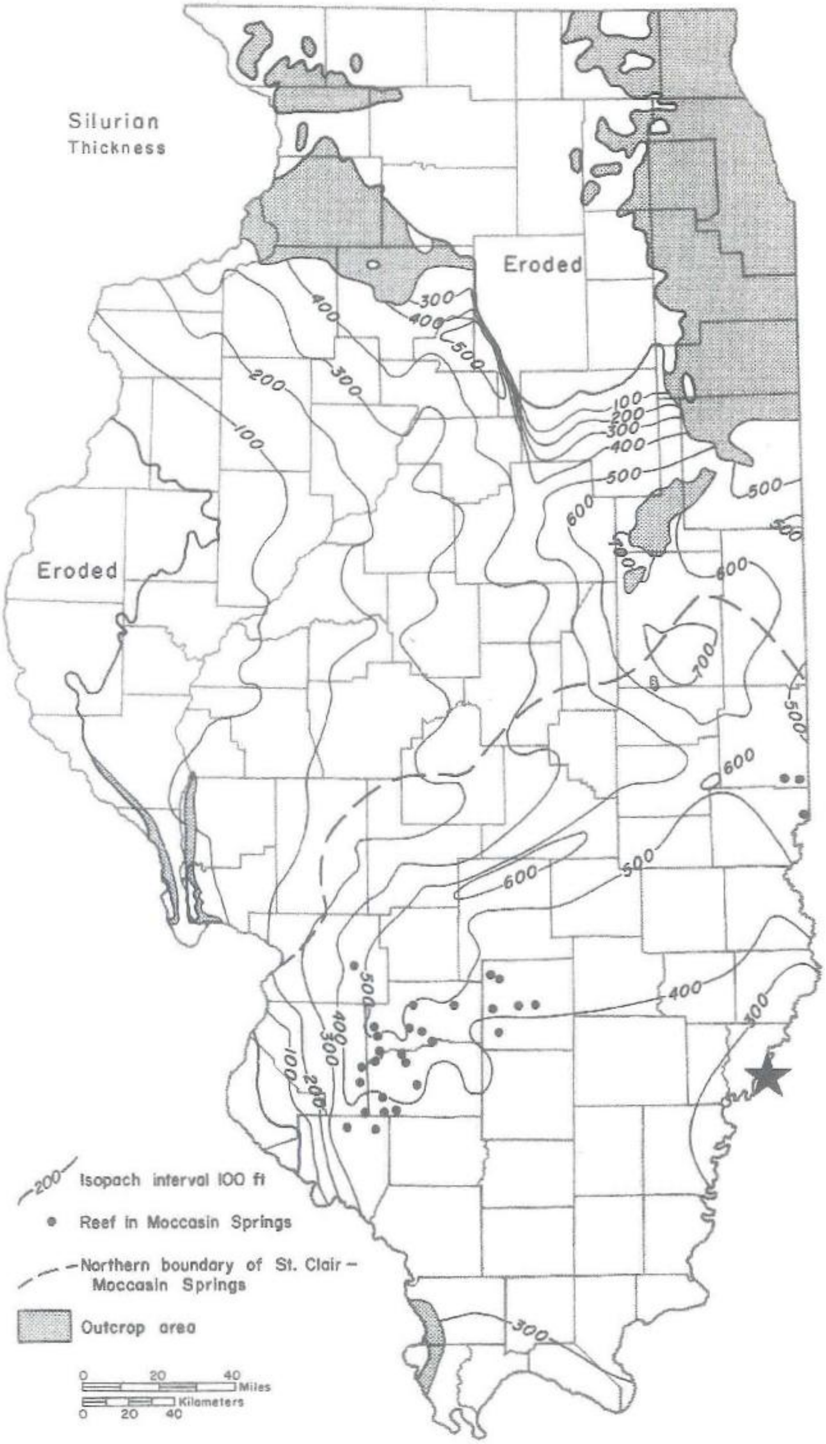
SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–40
PSI ENERGY, INC.
GIBSON GENERATING STATION
ISOPACH MAP OF THE SILURIAN SYSTEM AND LOCATION OF REEFS IN SOUTHWESTERN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: BECKER AND KELLER, 1976



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-41

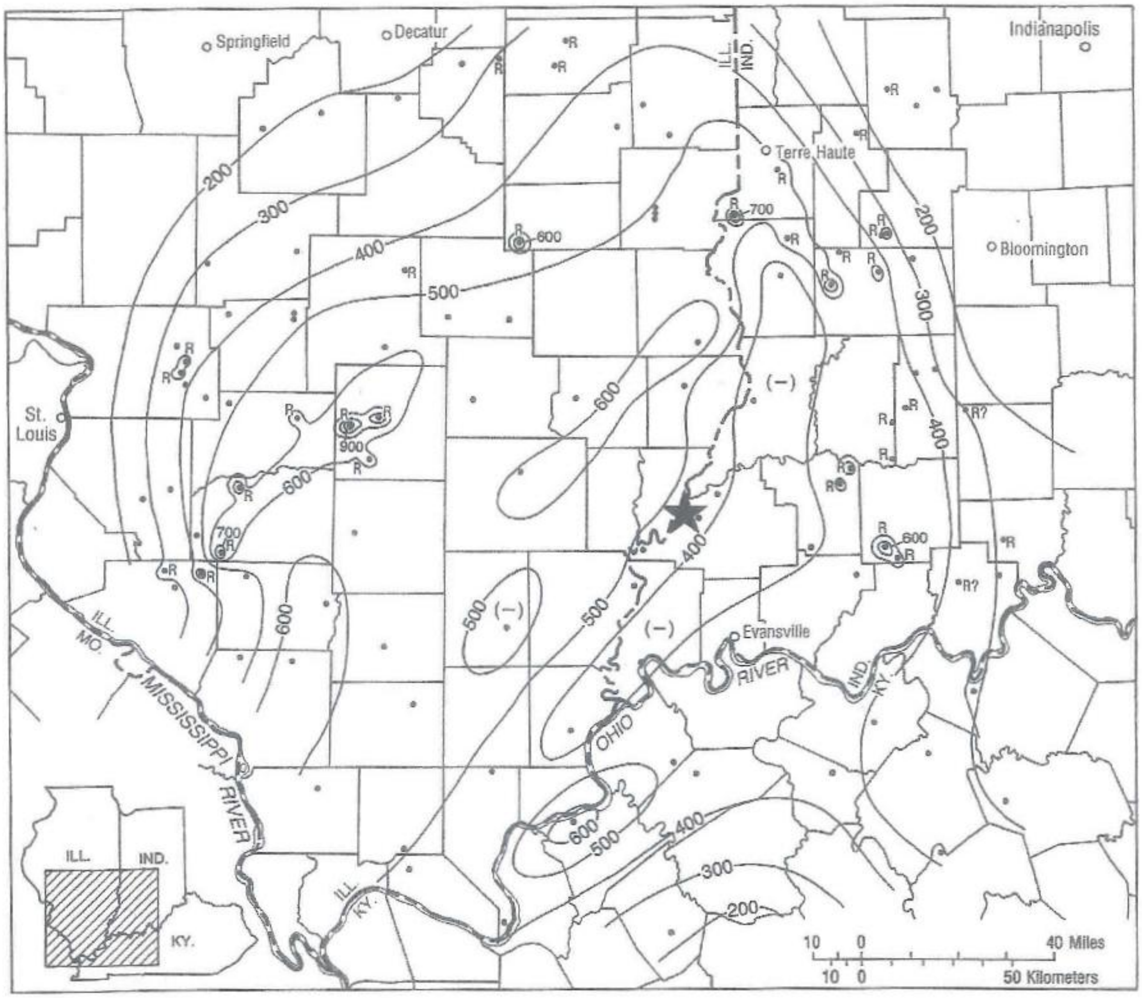
PSI ENERGY, INC.

GIBSON GENERATING STATION

ISOPACH MAP OF THE SILURIAN SYSTEM AND LOCATION OF REEFS IN THE MOCCASIN SPRINGS FORMATION IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

R INDICATES WELLS THAT PENETRATE REEFS AND THAT MAY YIELD THICKNESSES GREATER THAN REGIONAL THICKNESSES. CONTOUR INTERVAL IS 100 FEET.

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-42

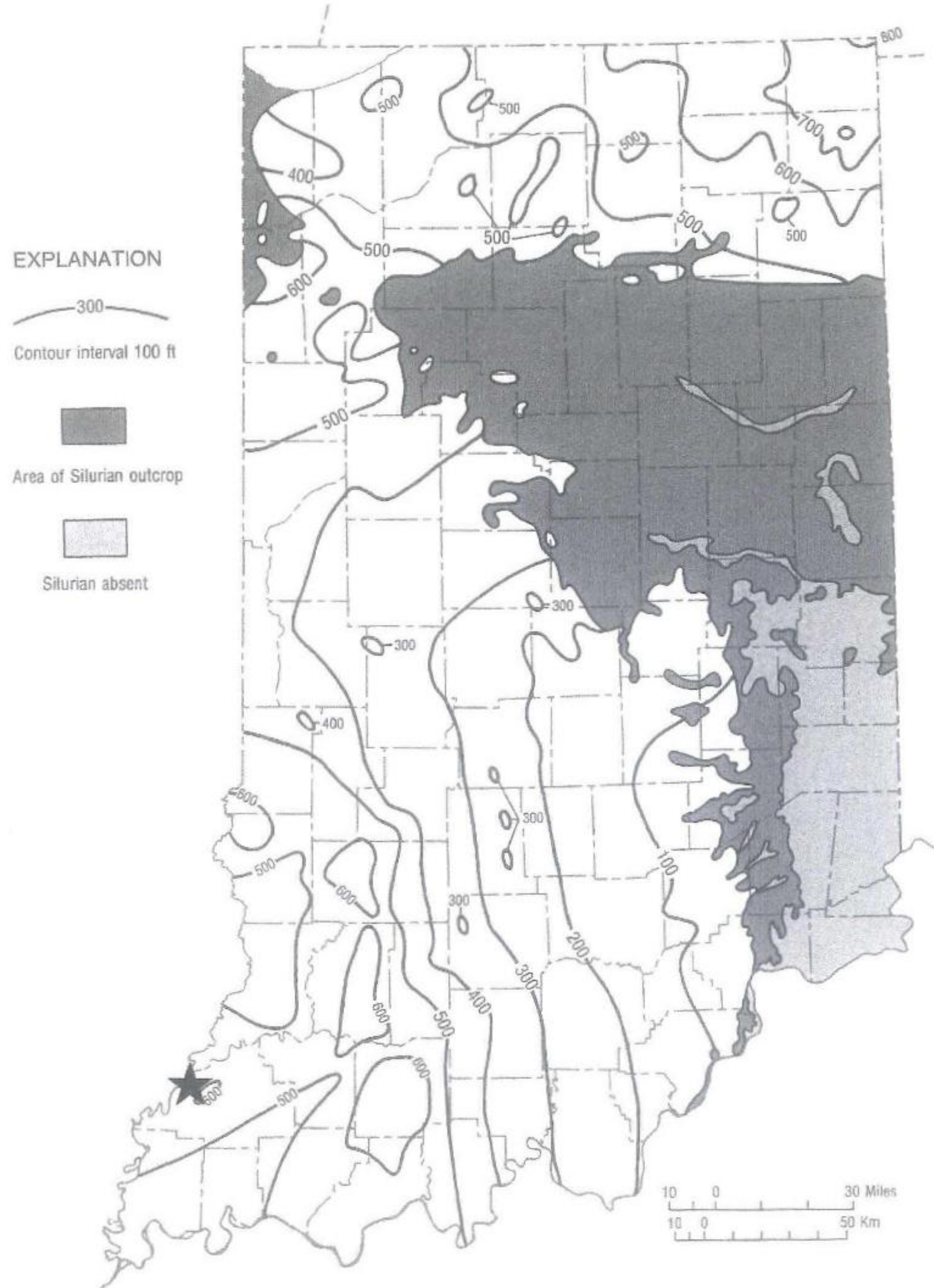
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE LOCATION OF REEFS IN THE AREA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND SHAVER, 1987



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-43

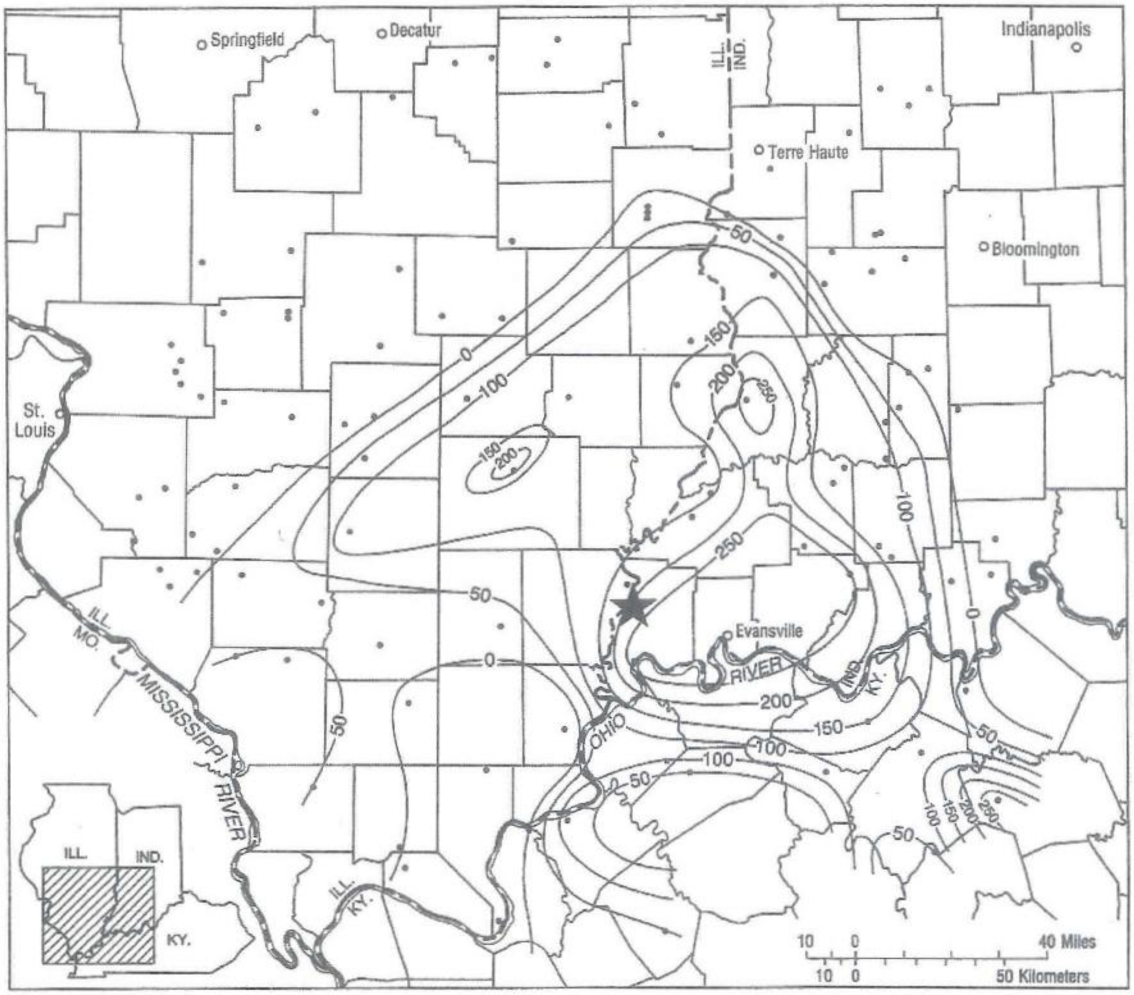
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE MOCCASIN SPRINGS FORMATION AND THE BAILEY LIMESTONE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

CONTOUR INTERVAL IS 50 FEET

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-44

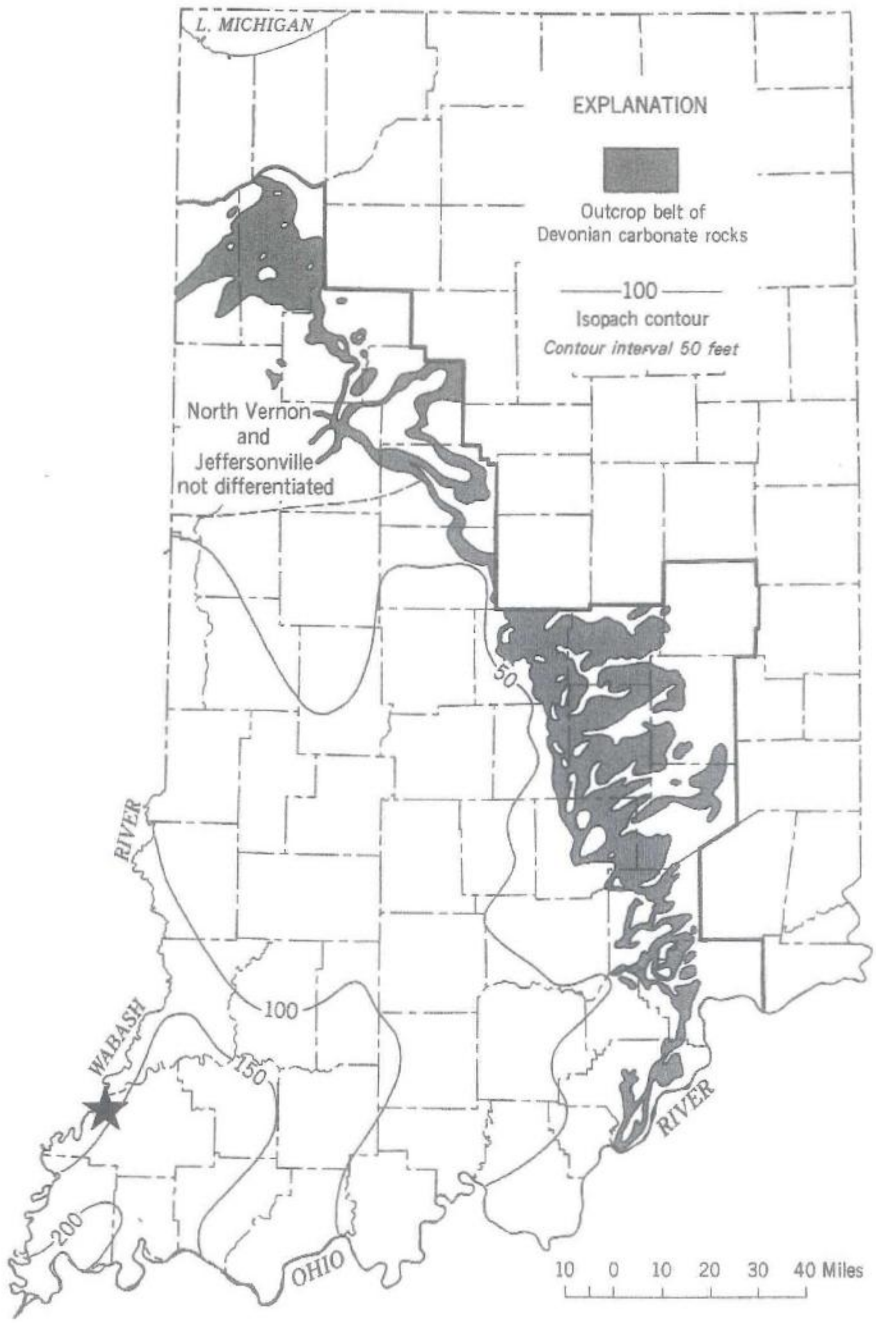
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE BACKBONE LIMESTONE IN THE ILLINOIS BASIN

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND SHAVER, 1987



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-45

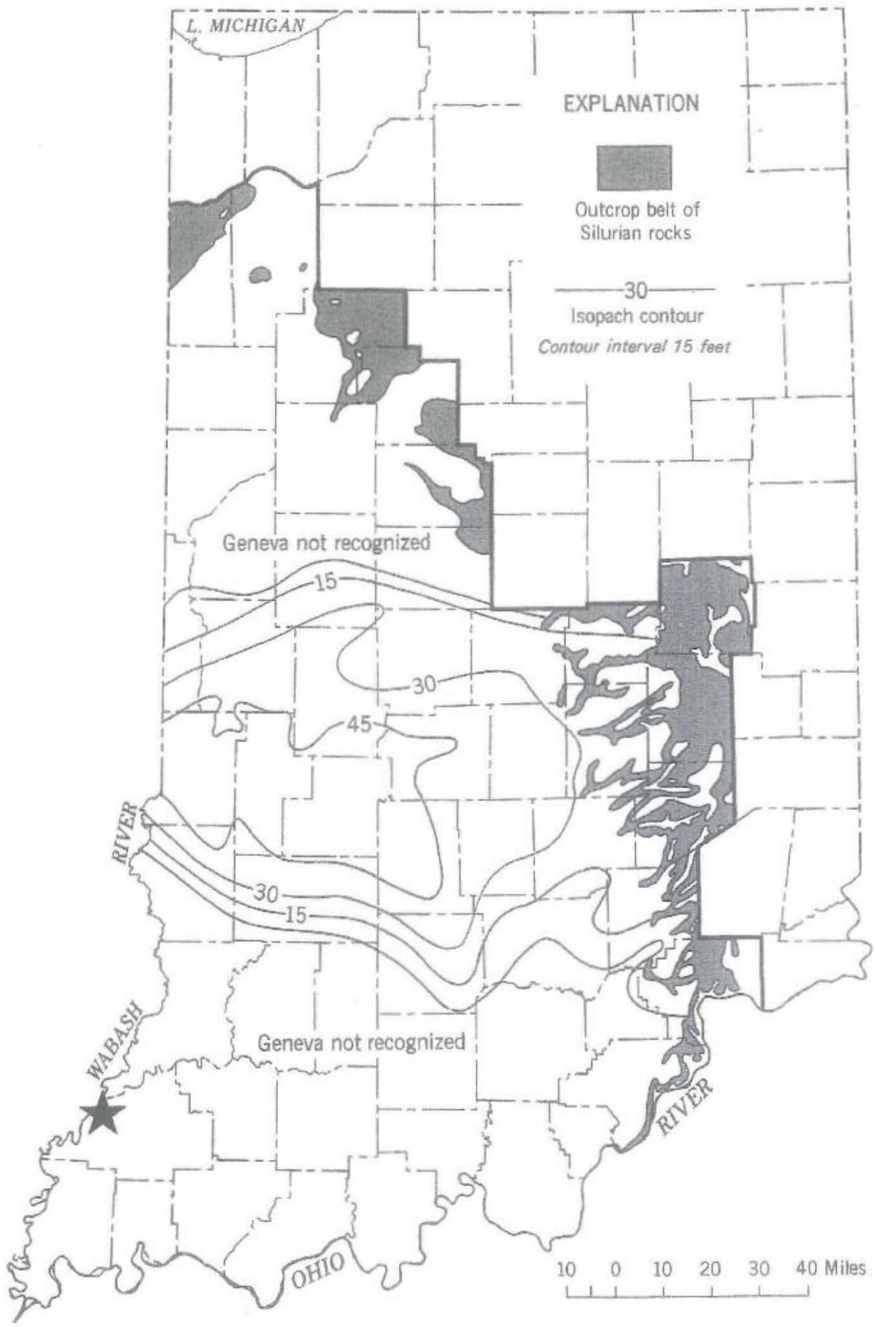
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE JEFFERSONVILLE LIMESTONE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: BECKER, 1974



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-46

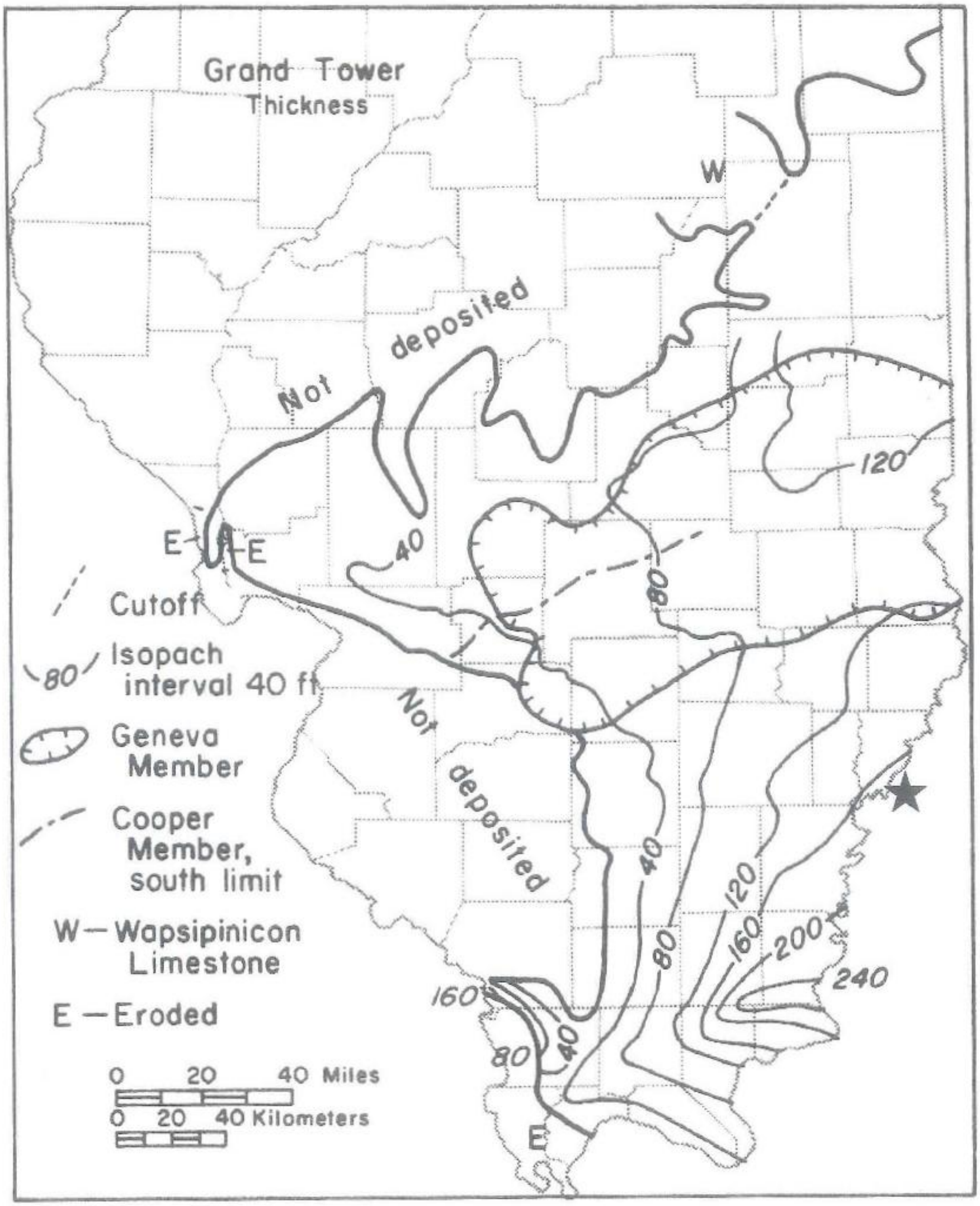
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE GENEVA DOLOMITE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: BECKER, 1974



LEGEND

★ SITE LOCATION

SOURCE: WILLMAN, et al, 1975

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

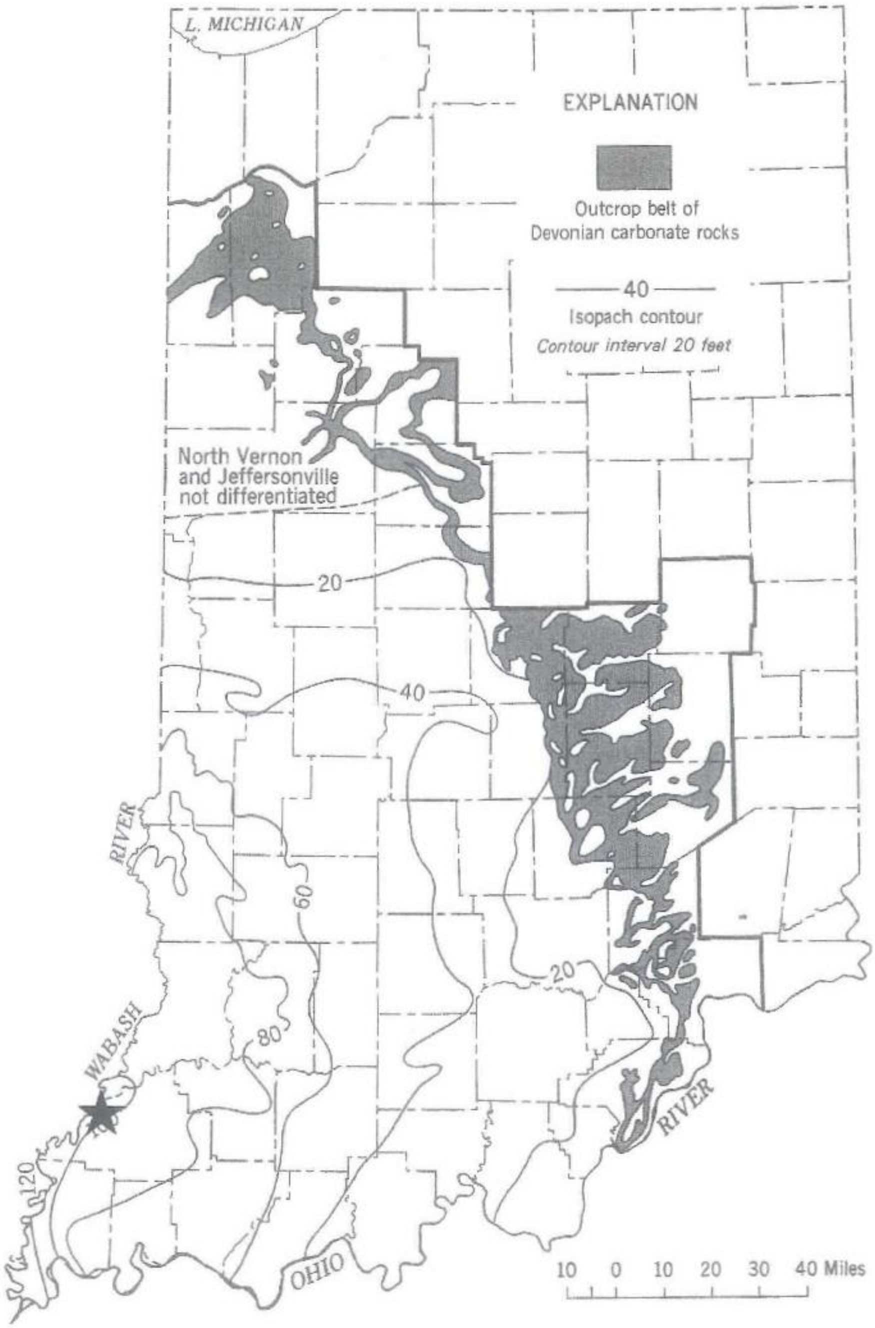
FIGURE F-47

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE GRAND TOWER LIMESTONE IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–48

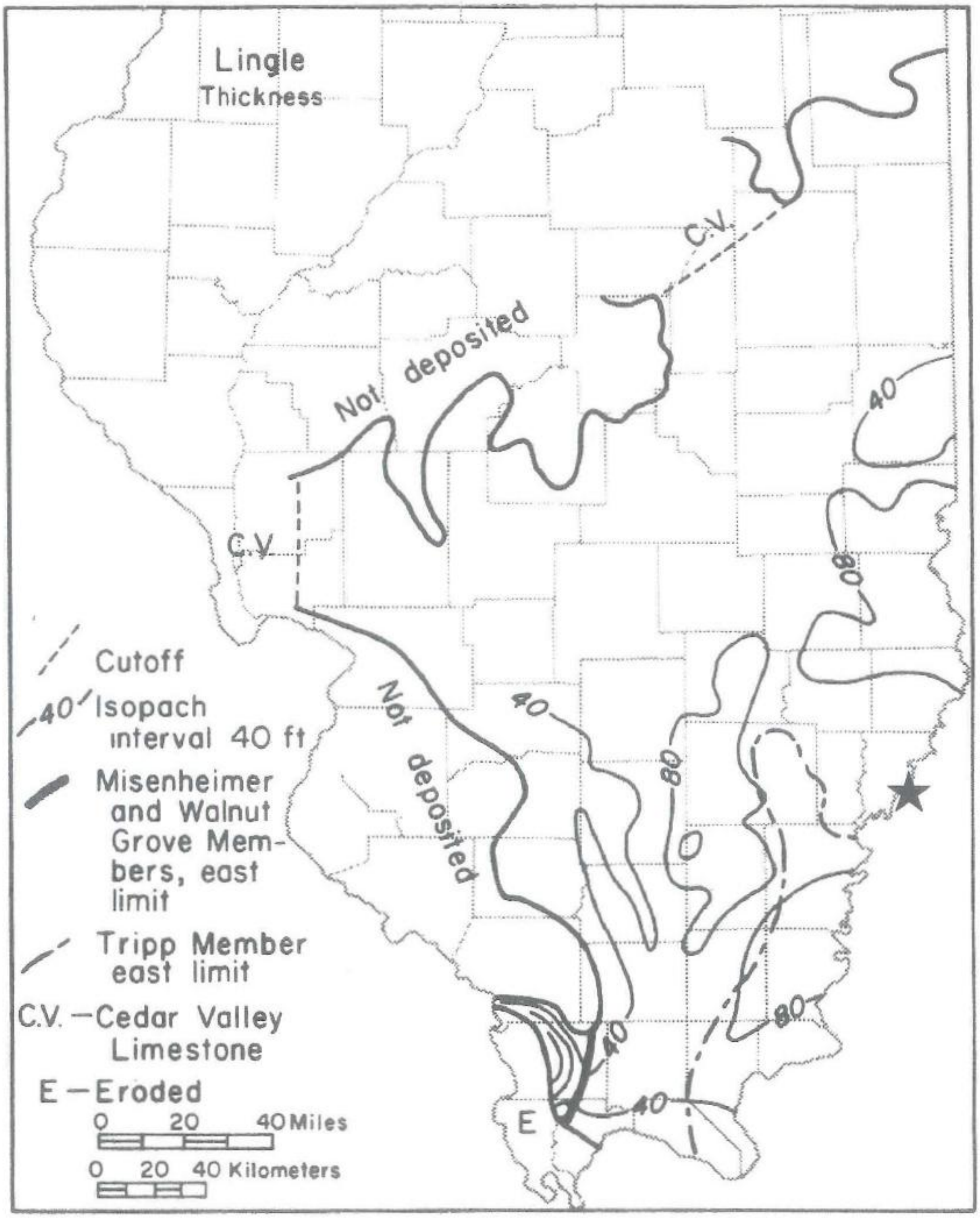
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE NORTH VERNON LIMESTONE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: BECKER, 1974



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-49

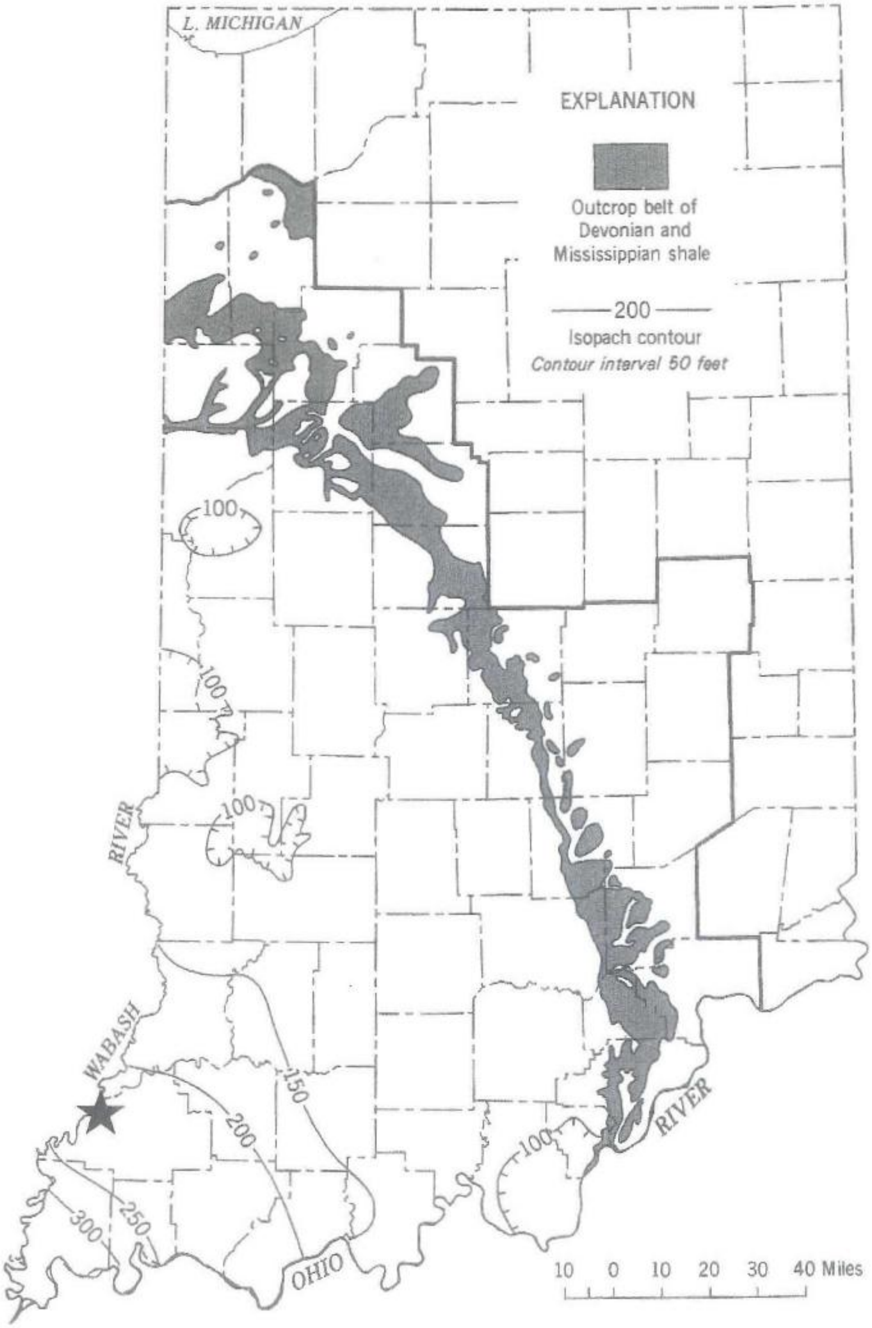
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE LINGLE FORMATION IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

Thickness
Estimation of
USDW 70±

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-50

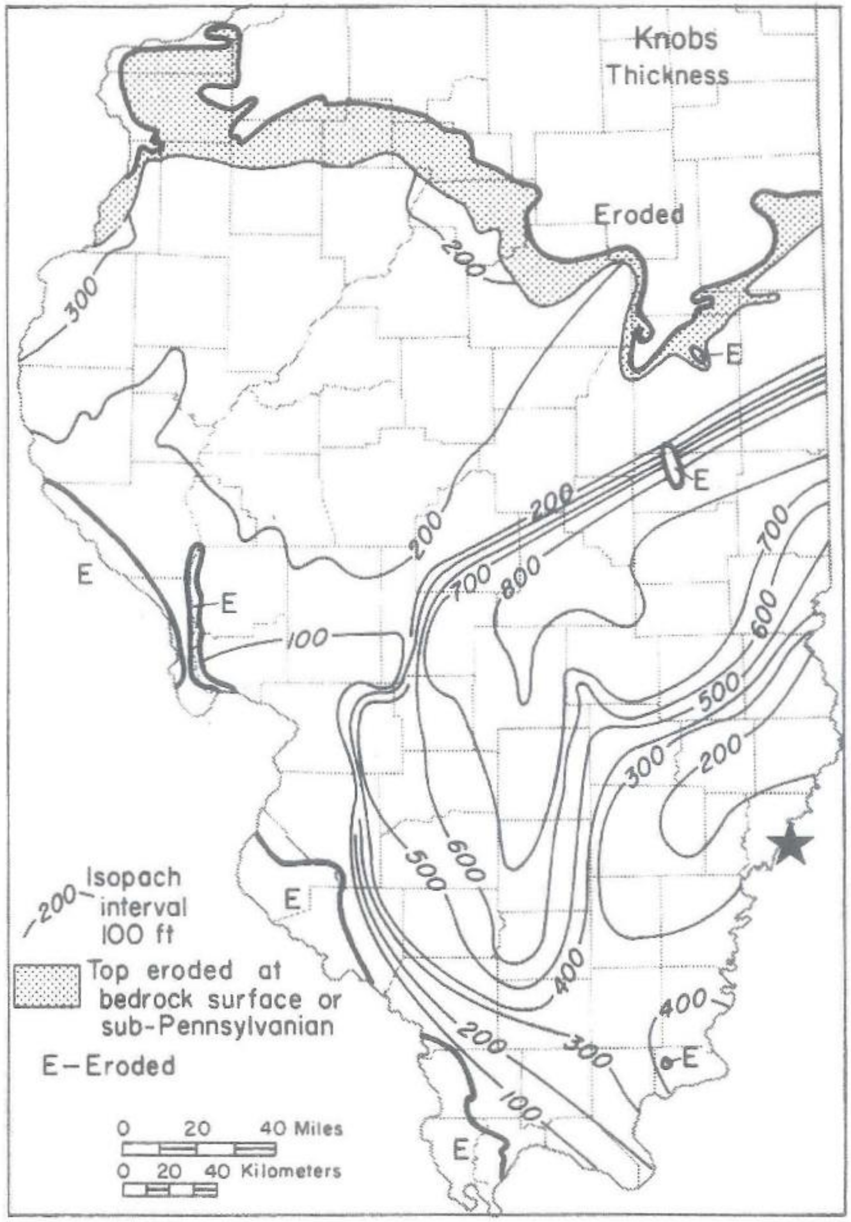
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE NEW ALBANY SHALE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: BECKER, 1974



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–51

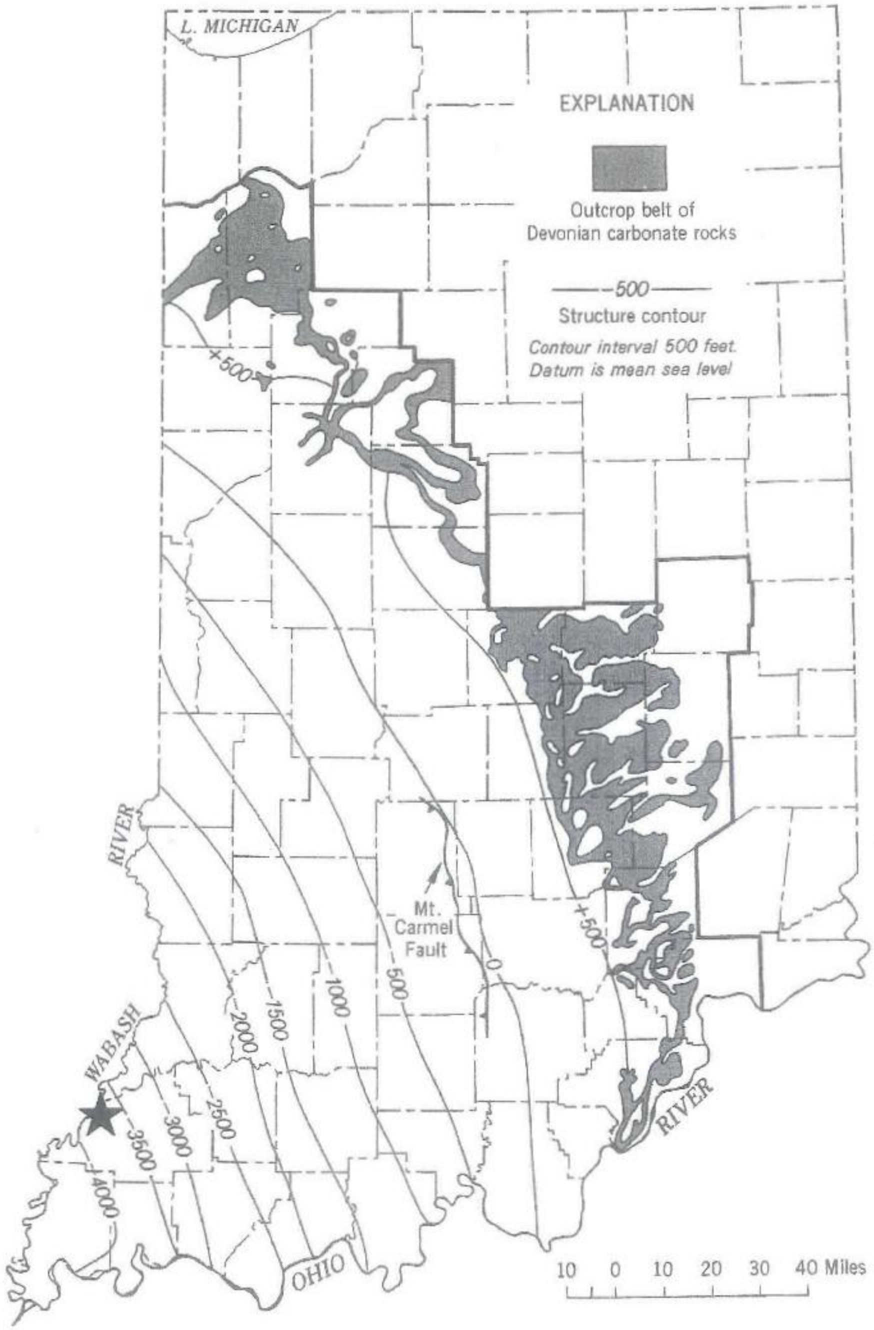
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE KNOBS MEGAGROUP IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–52

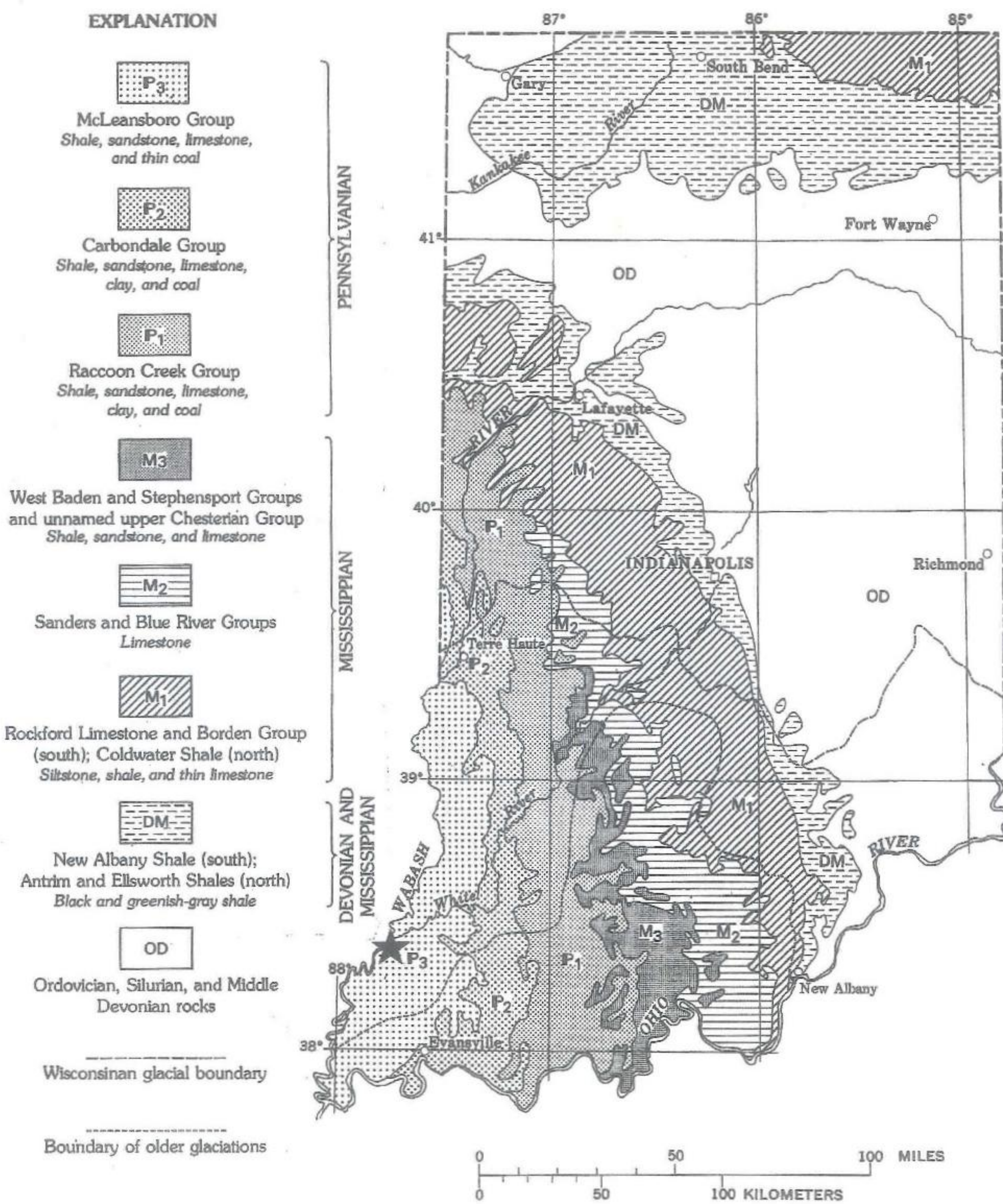
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE STRUCTURE ON THE BASE OF THE NEW ALBANY SHALE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: BECKER, 1974



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–53

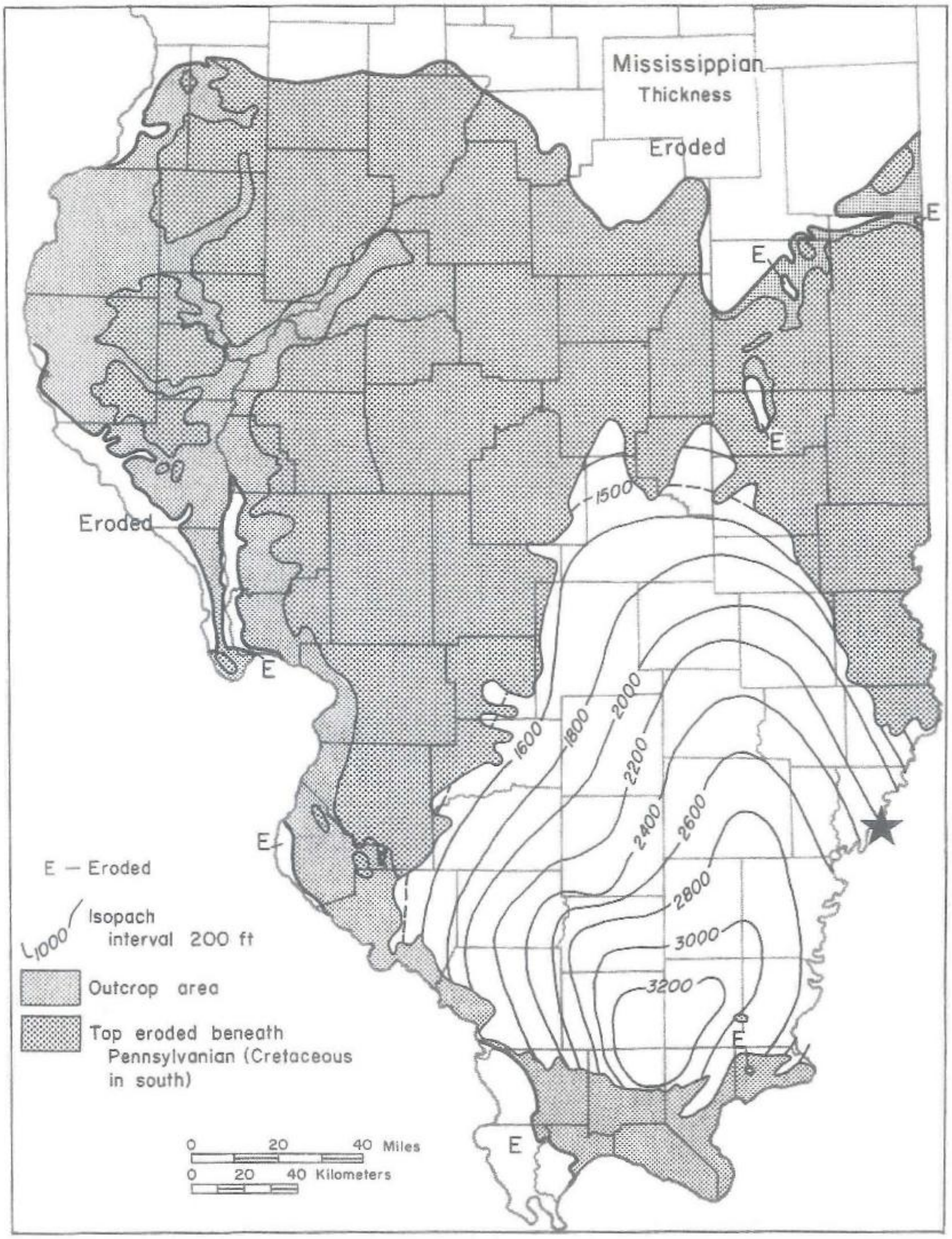
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE DISTRIBUTION OF MISSISSIPPIAN AND PENNSYLVANIAN ROCKS IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: GRAY, 1979



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–54

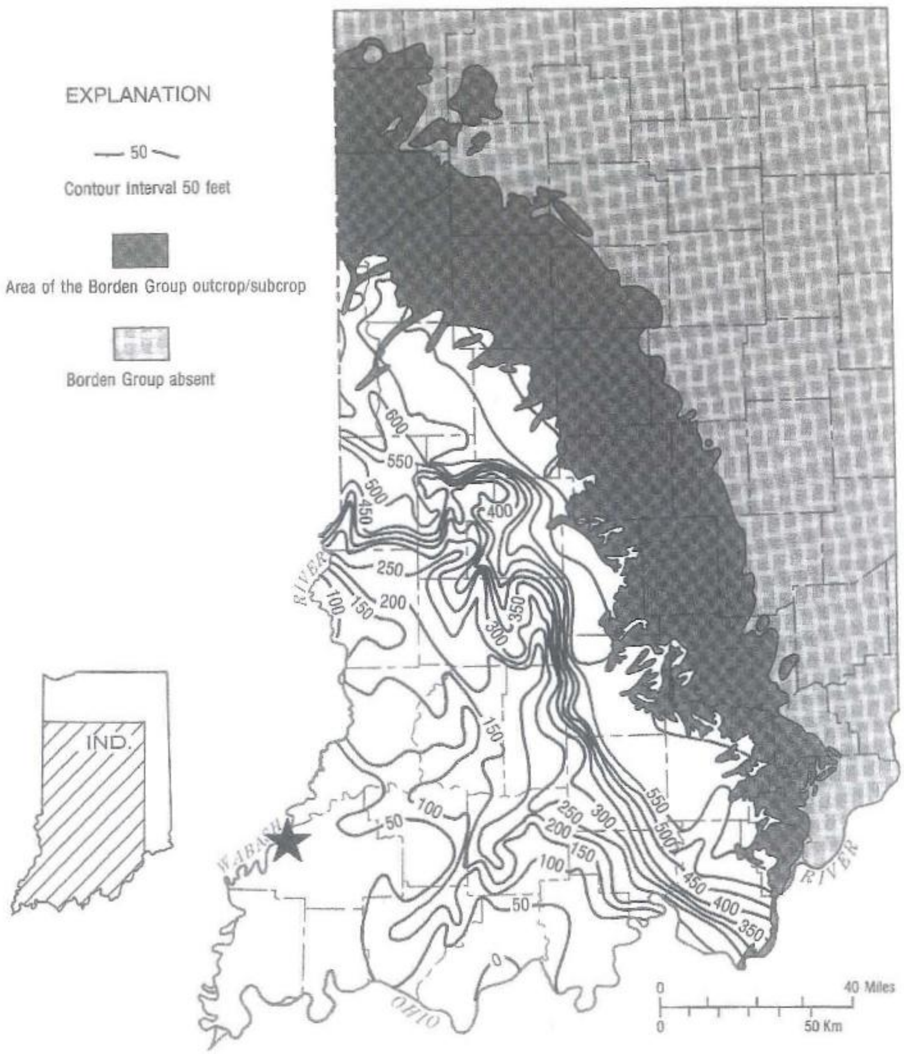
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE DISTRIBUTION OF MISSISSIPPIAN ROCKS IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–55

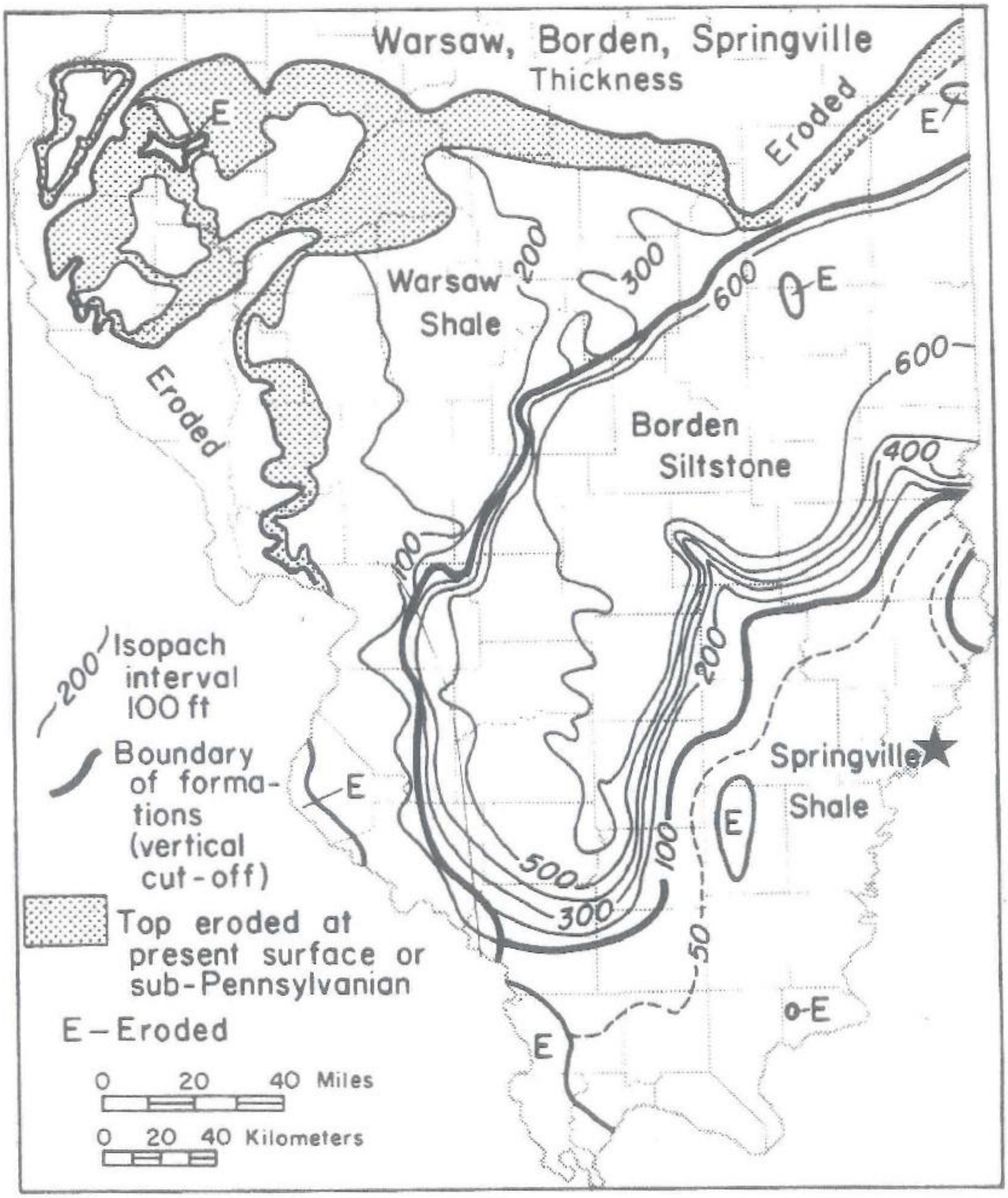
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE BORDEN GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–56

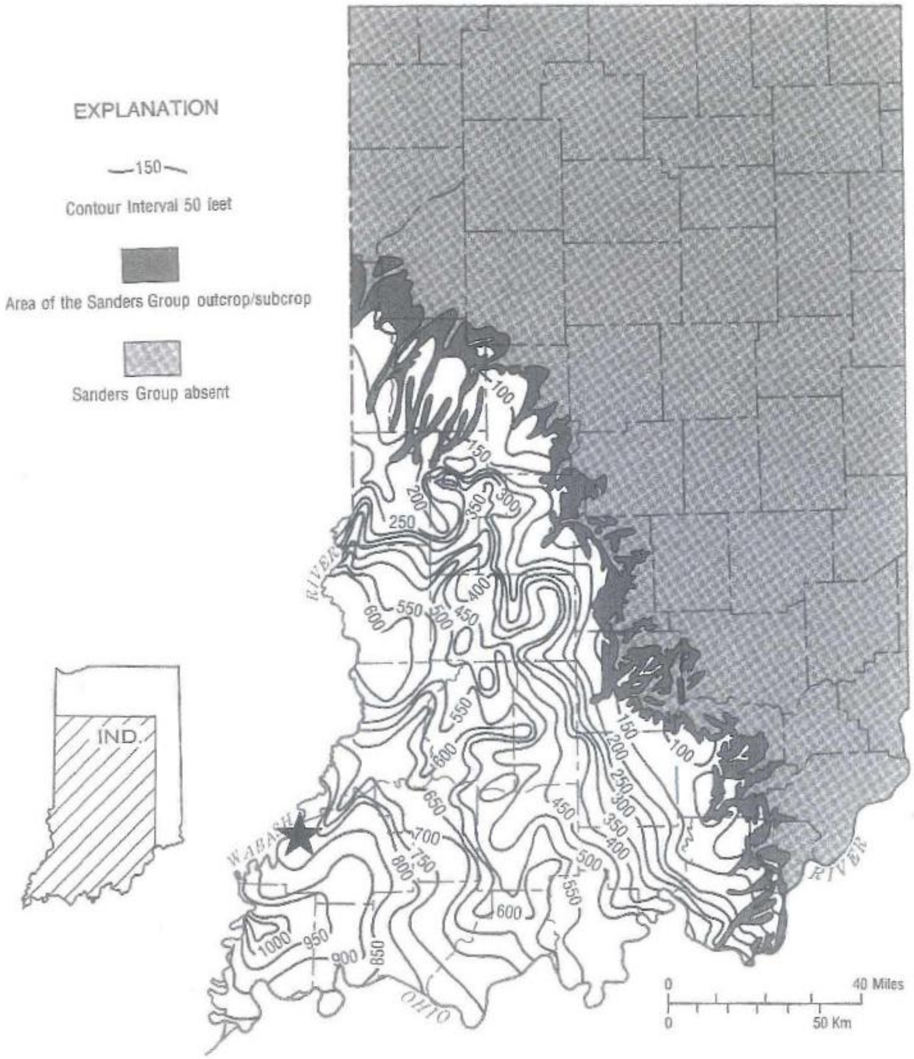
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE WARSAW SHALE, BORDEN SILTSTONE, AND SPRINGVILLE SHALE IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-57

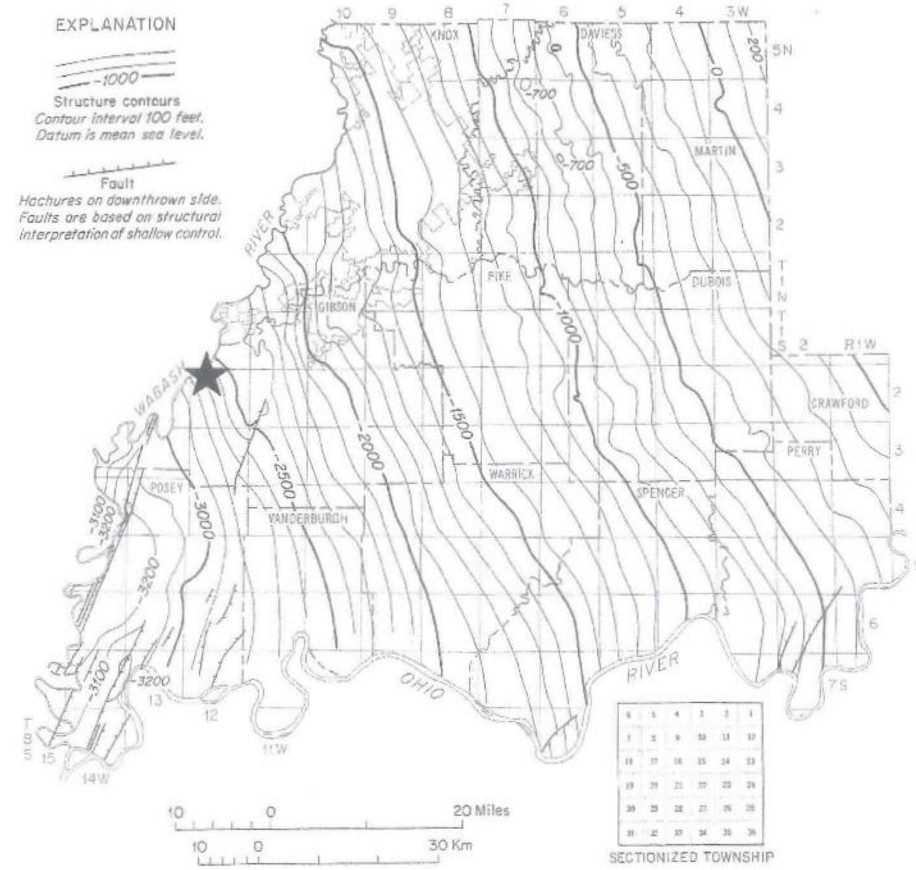
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE SANDERS GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–58

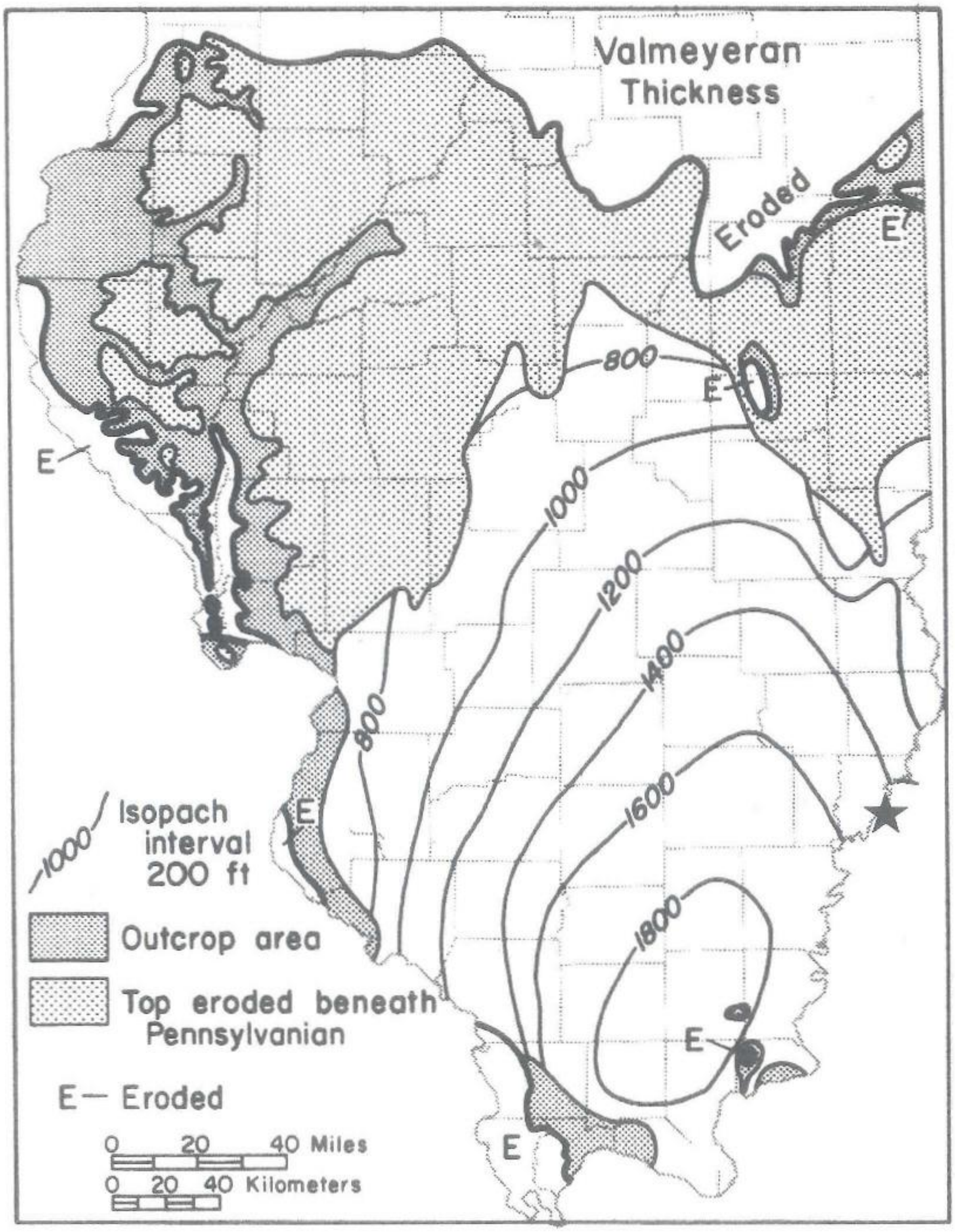
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE STRUCTURE ON TOP OF THE SALEM LIMESTONE IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: KELLER AND BECKER, 1980



LEGEND

★ SITE LOCATION

SOURCE: WILLMAN, et al, 1975

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

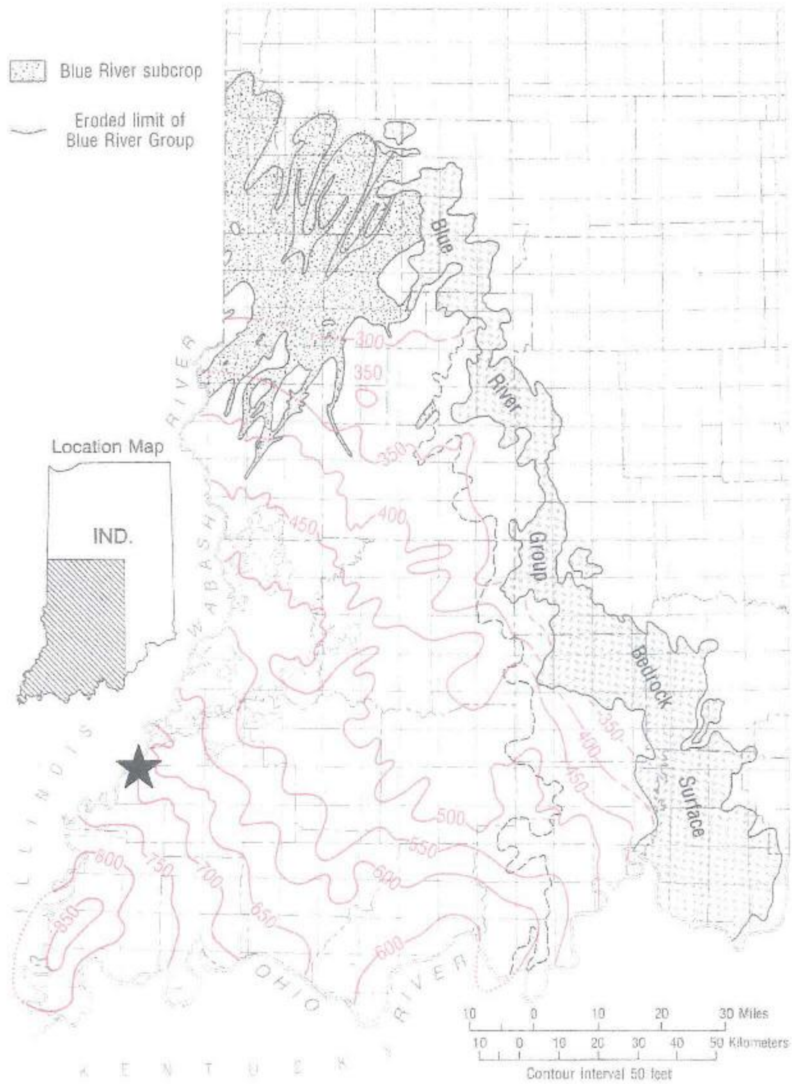
FIGURE F-59

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE VALMEYERAN SERIES IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-60

PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE BLUE RIVER GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND CARPENTER, 1990

240

Contour Interval 20 feet

Area of the West Baden Group outcrop/subcrop

West Baden Group absent

40-80 feet thick

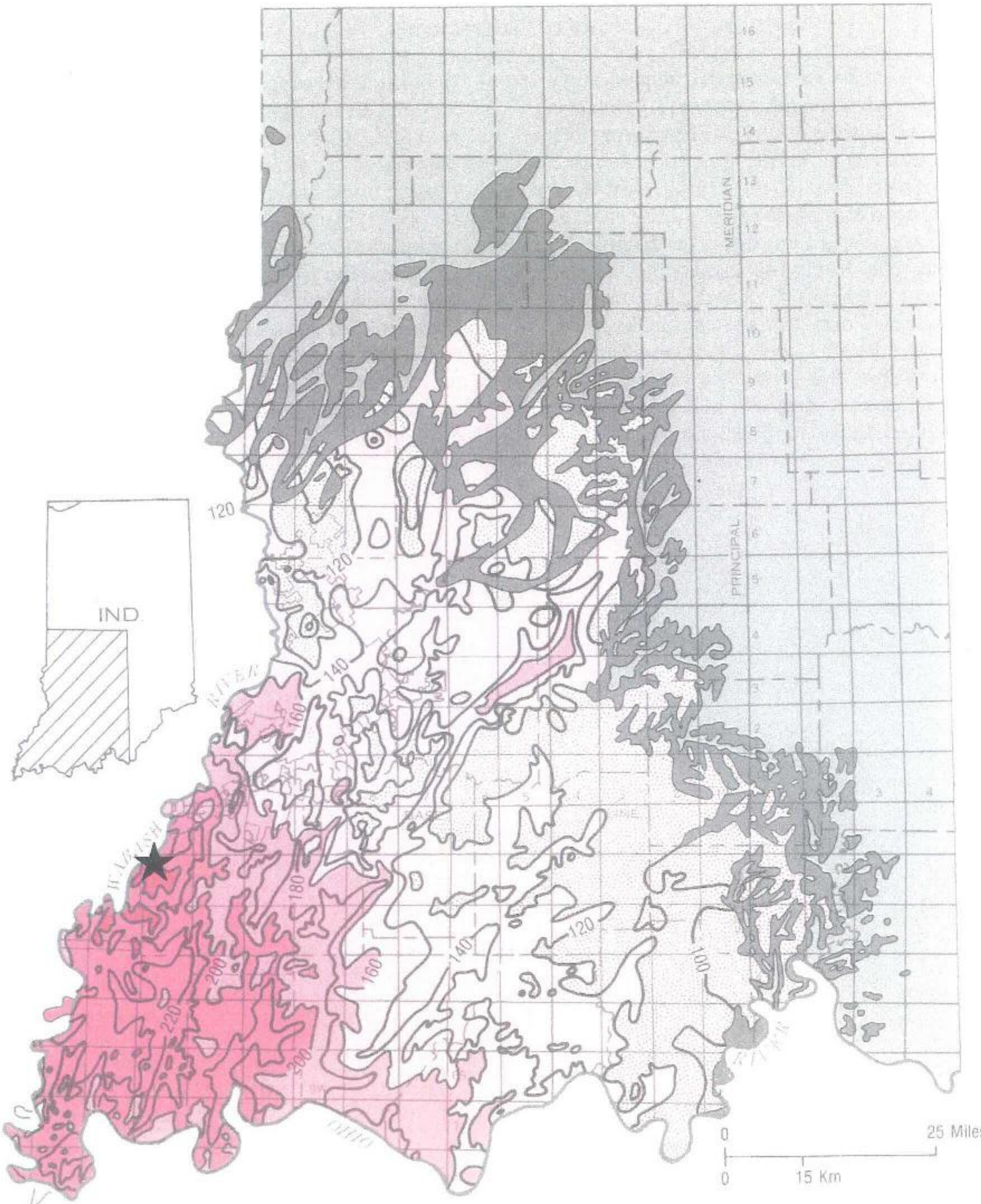
80-120 feet thick

120-160 feet thick

160-200 feet thick

200-240 feet thick

>240 feet thick



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-61

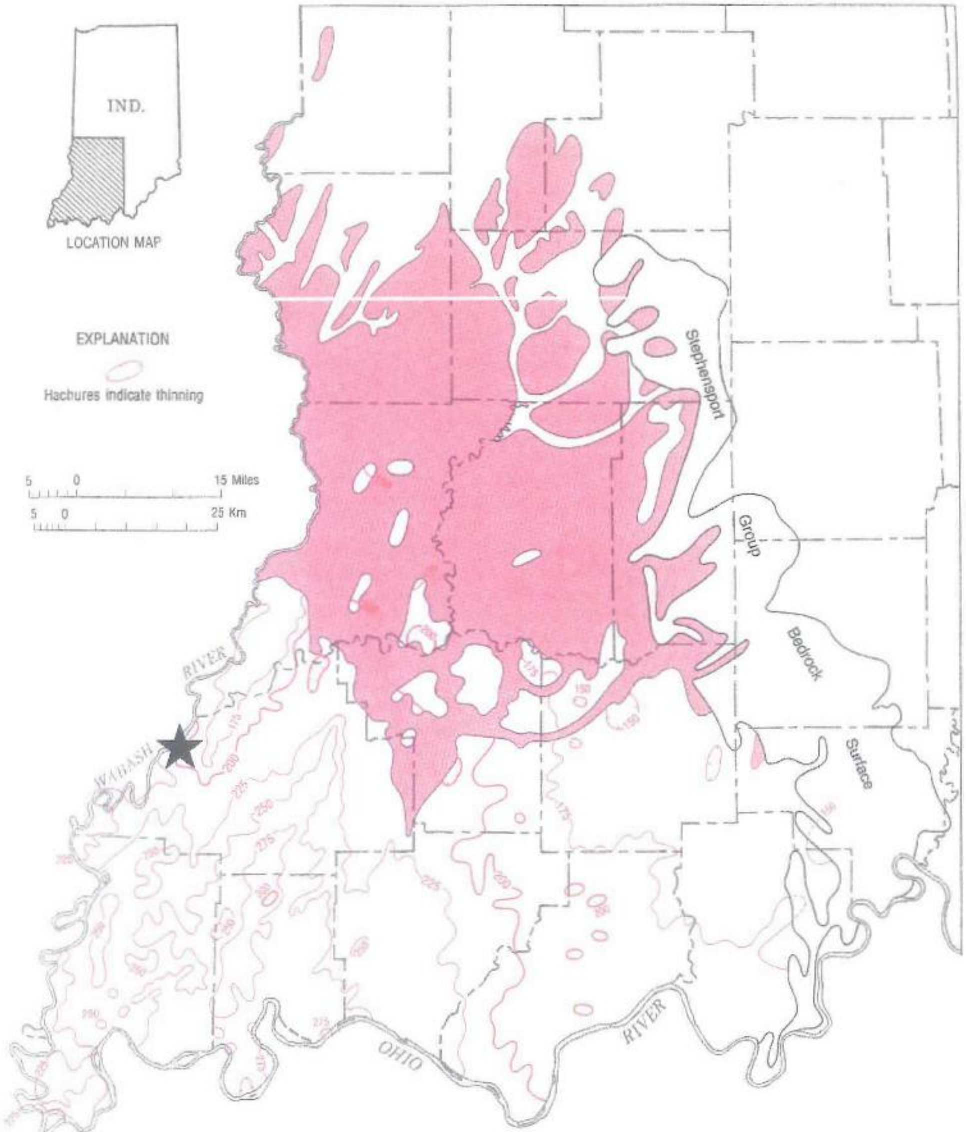
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE WEST BADEN GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-62

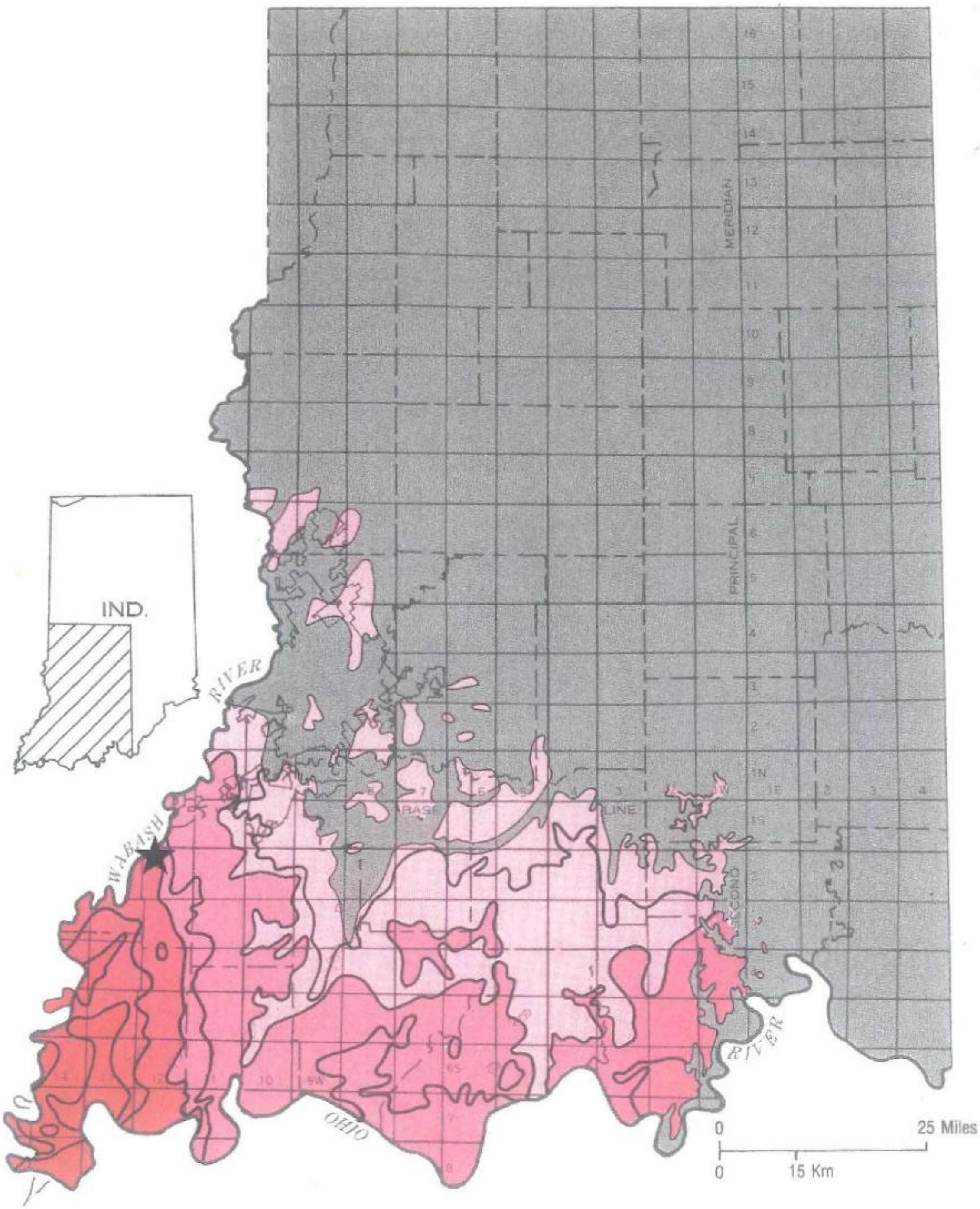
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE STEPHENSPORT GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND KELLER, 1995



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-63

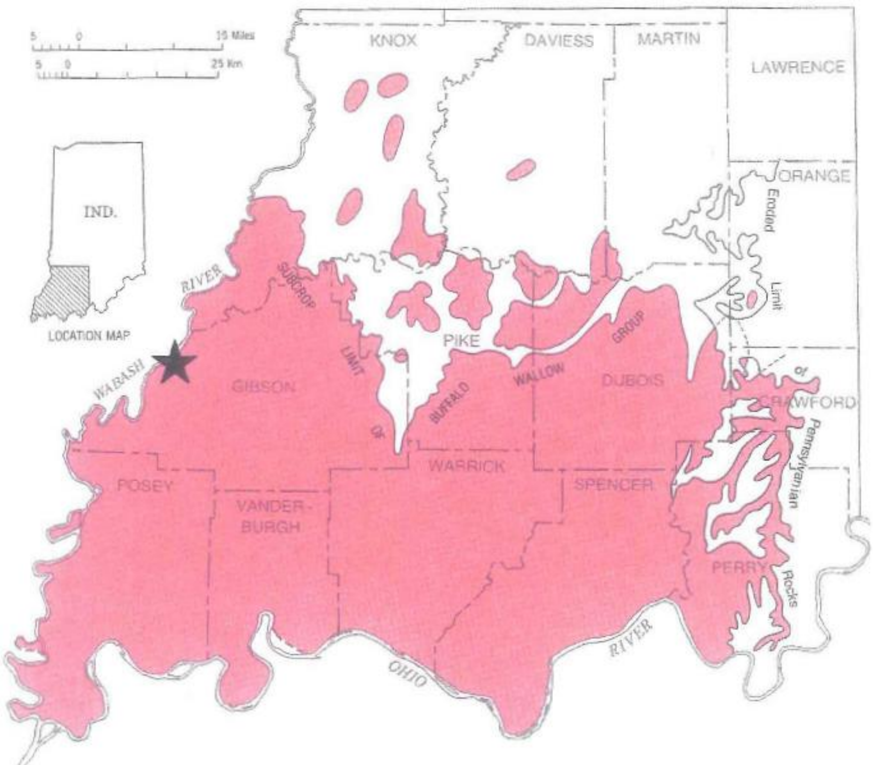
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE BUFFALO WALLOW GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-64

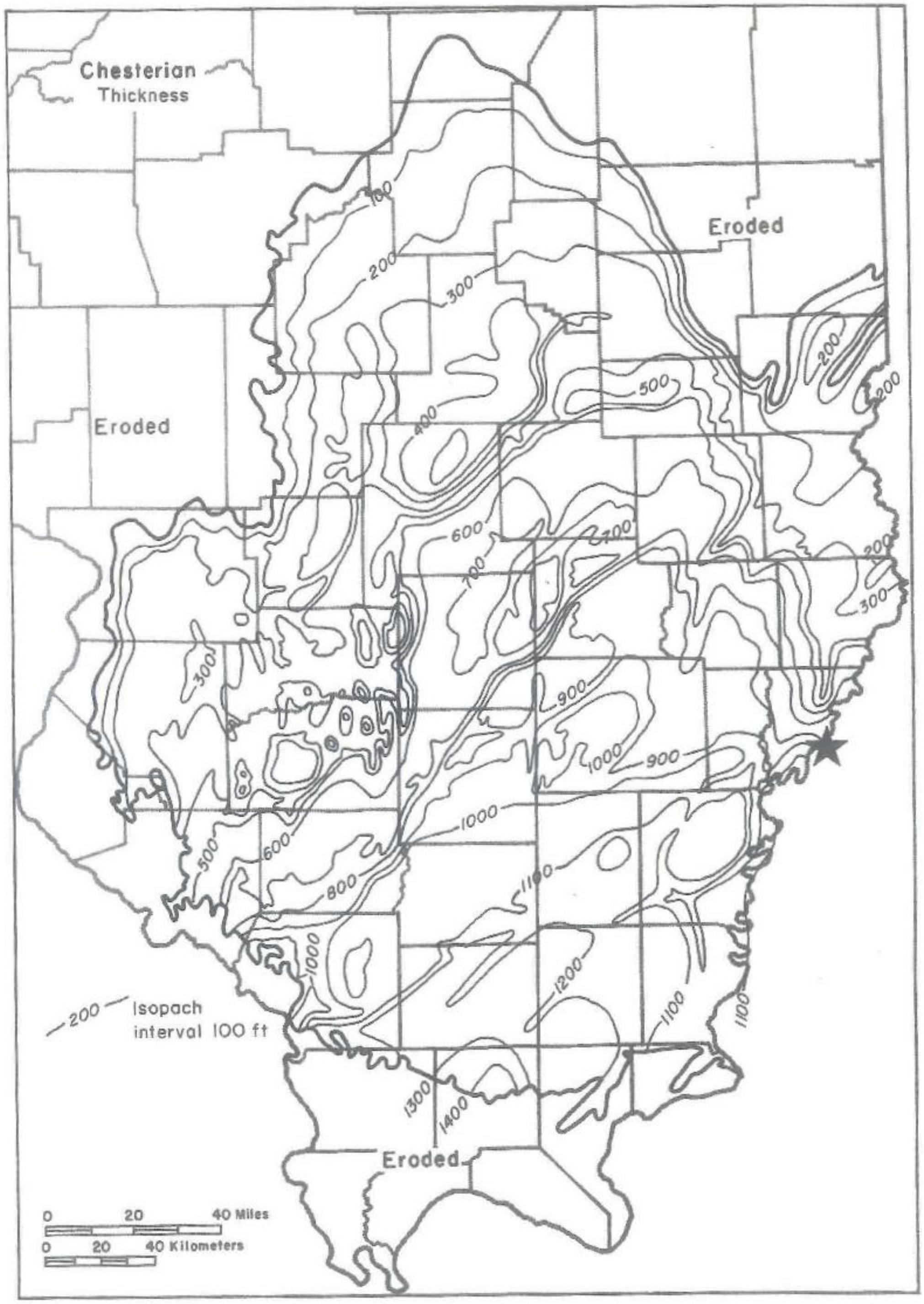
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE SUBCROP LIMIT OF THE BUFFALO WALLOW GROUP IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND KELLER, 1995



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–65

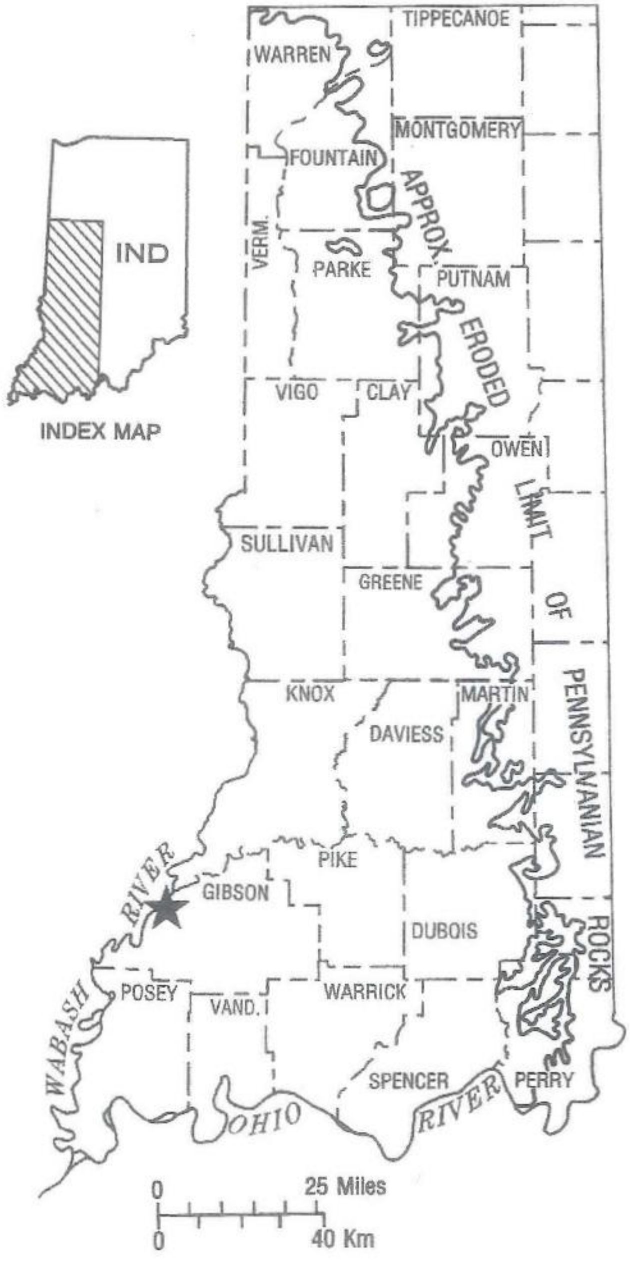
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE CHESTERIAN SERIES IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



LEGEND

★ SITE LOCATION

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–66

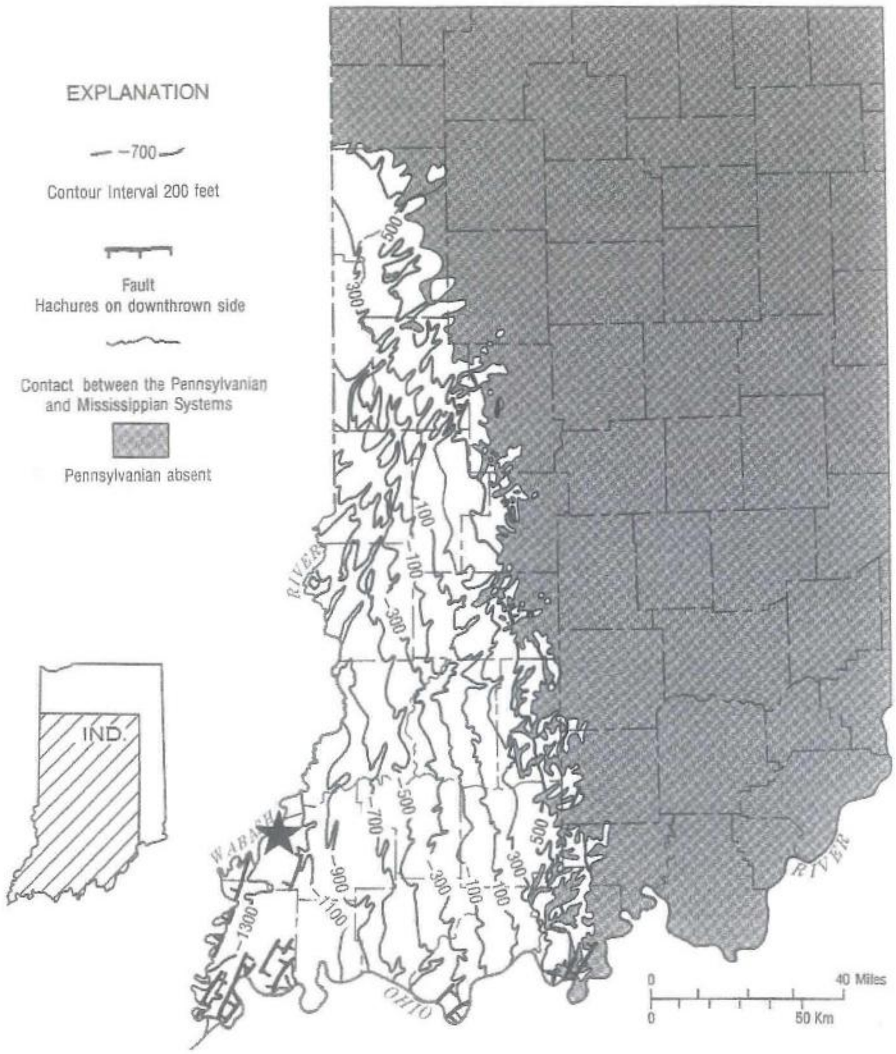
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE APPROXIMATE ERODED LIMIT OF PENNSYLVANIAN ROCKS IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: DROSTE AND KELLER, 1989



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–67

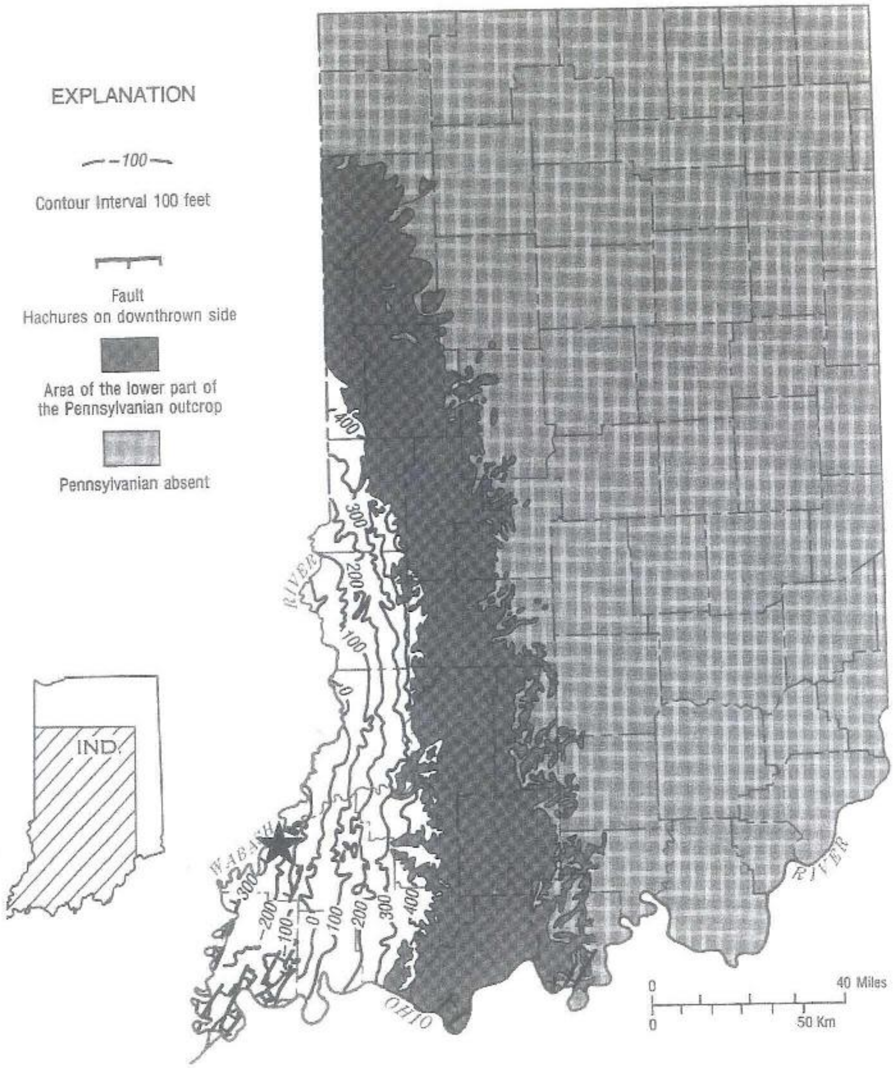
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE STRUCTURE ON THE BASE OF THE PENNSYLVANIAN SYSTEM IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-68

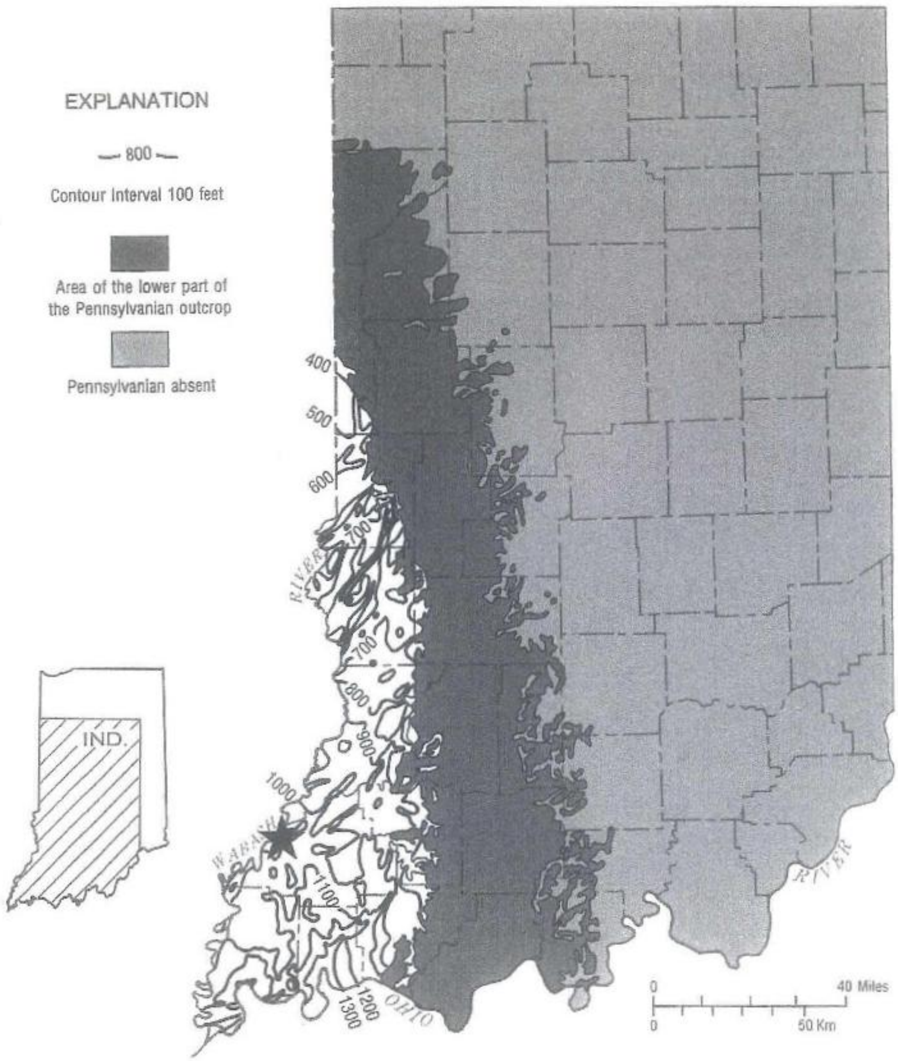
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE STRUCTURE ON TOP OF THE SPRINGFIELD COAL MEMBER OF THE PETERSBURG FORMATION IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-69

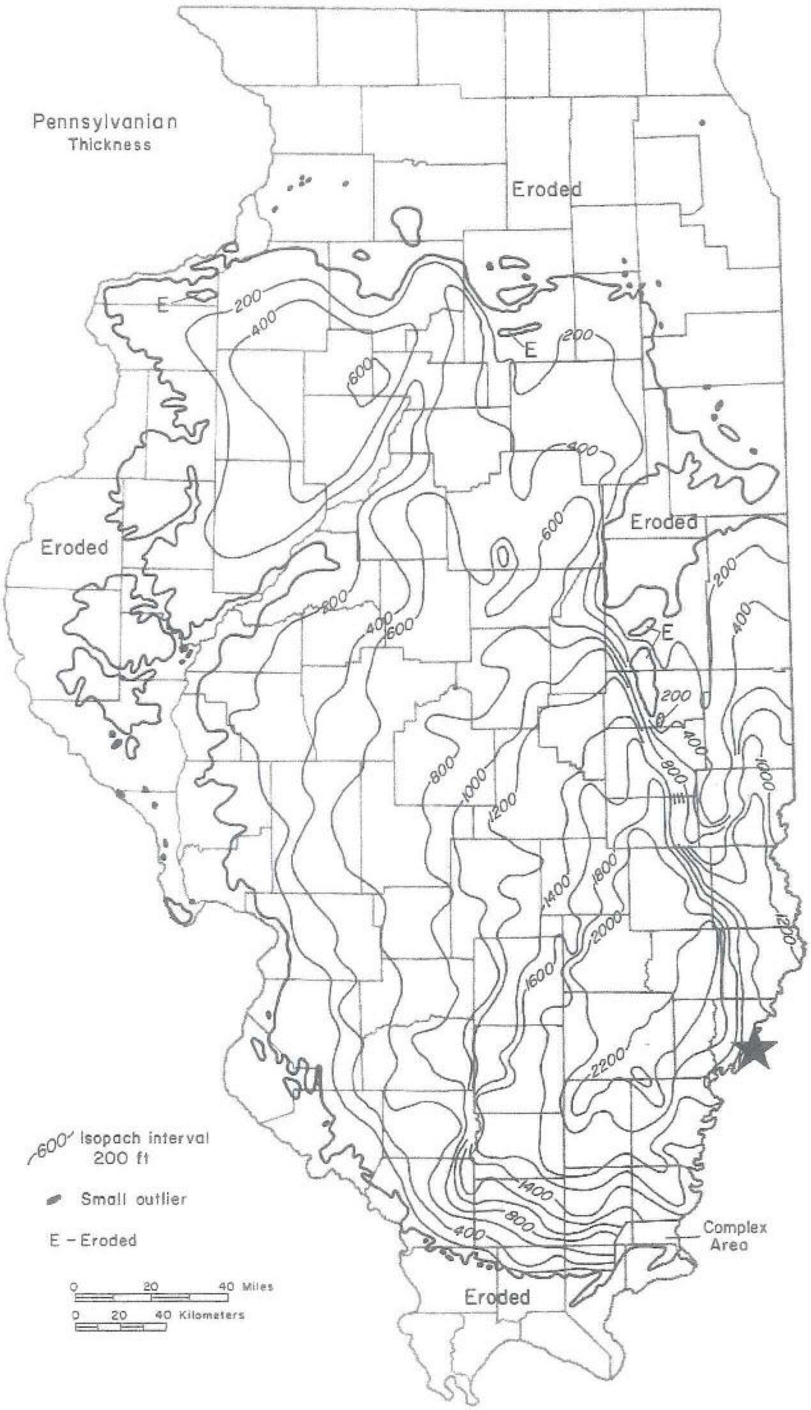
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF THE LOWER PART OF THE PENNSYLVANIAN SYSTEM IN INDIANA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUPP, 1991



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-70

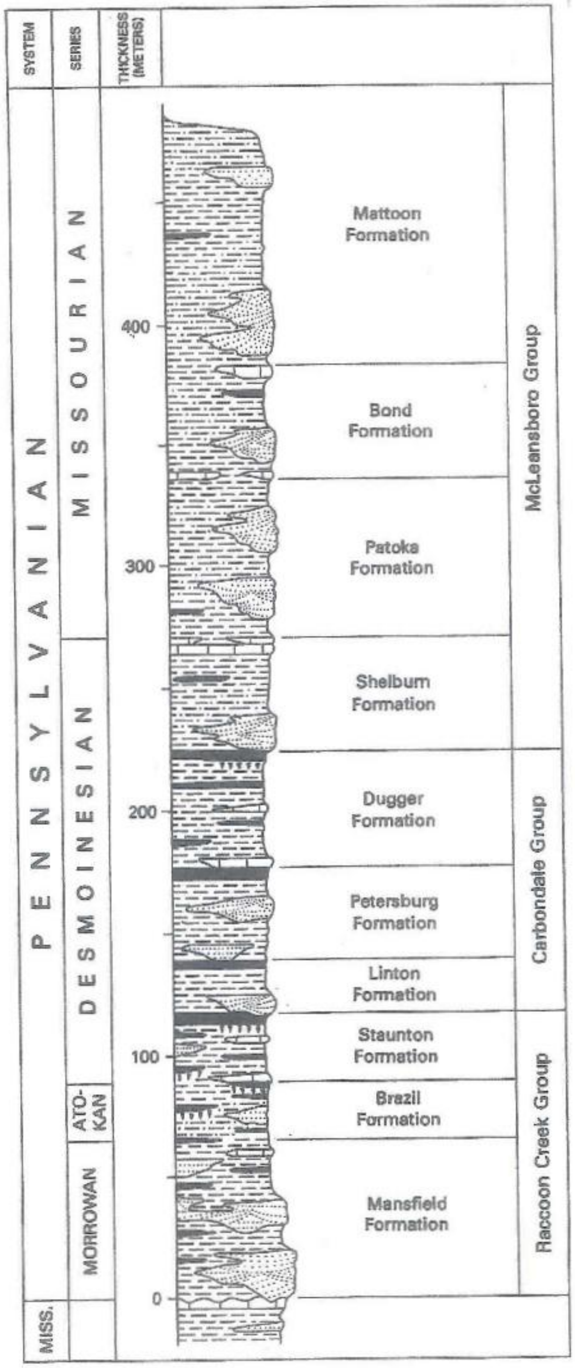
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP SHOWING THE THICKNESS OF
THE PENNSYLVANIAN SYSTEM IN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: WILLMAN, et al, 1975



N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–71

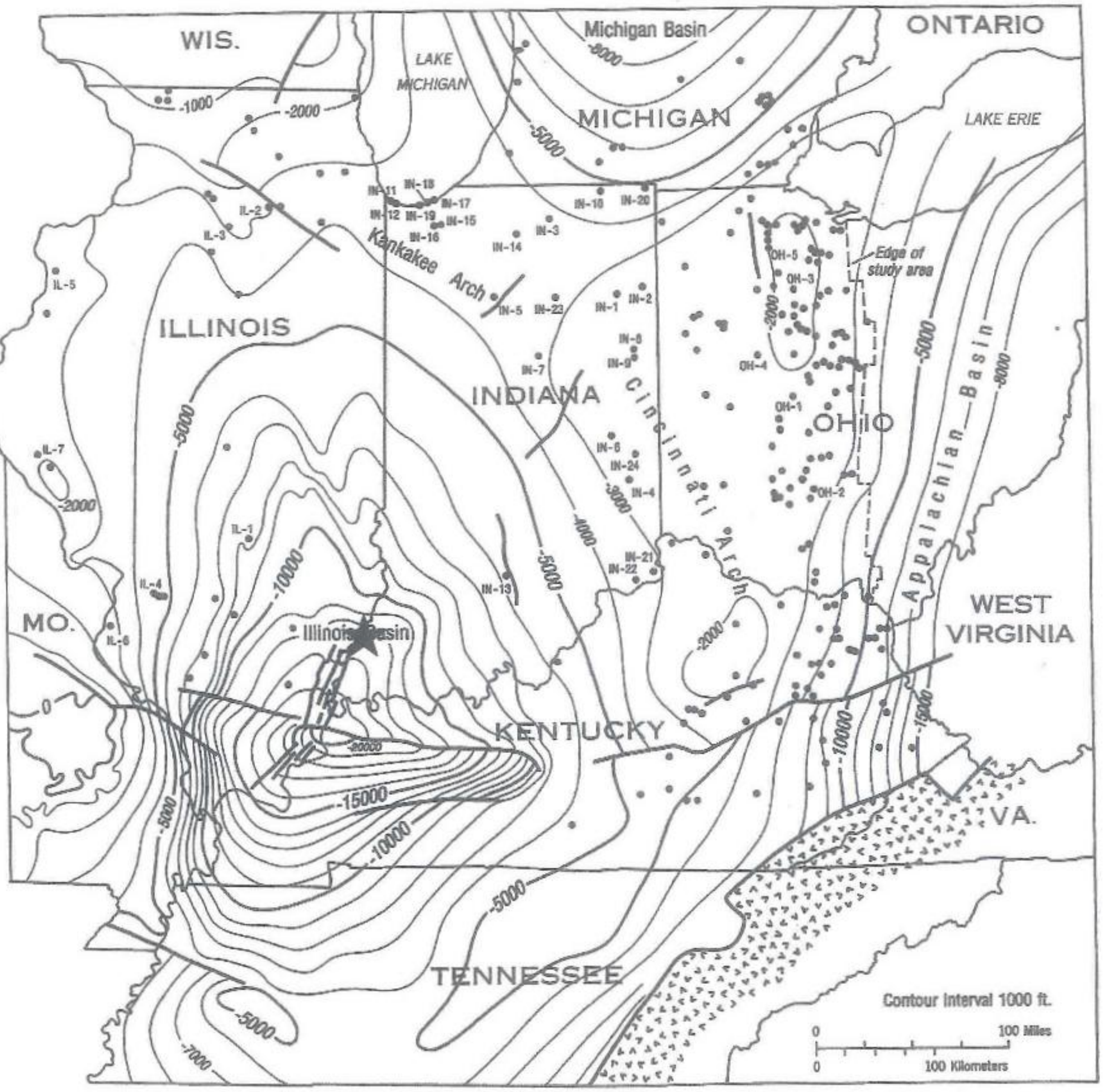
PSI ENERGY, INC.

GIBSON GENERATING STATION

COLUMNAR SECTION SHOWING
EXPOSED PENNSYLVANIAN ROCKS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: GRAY, 1979



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–72

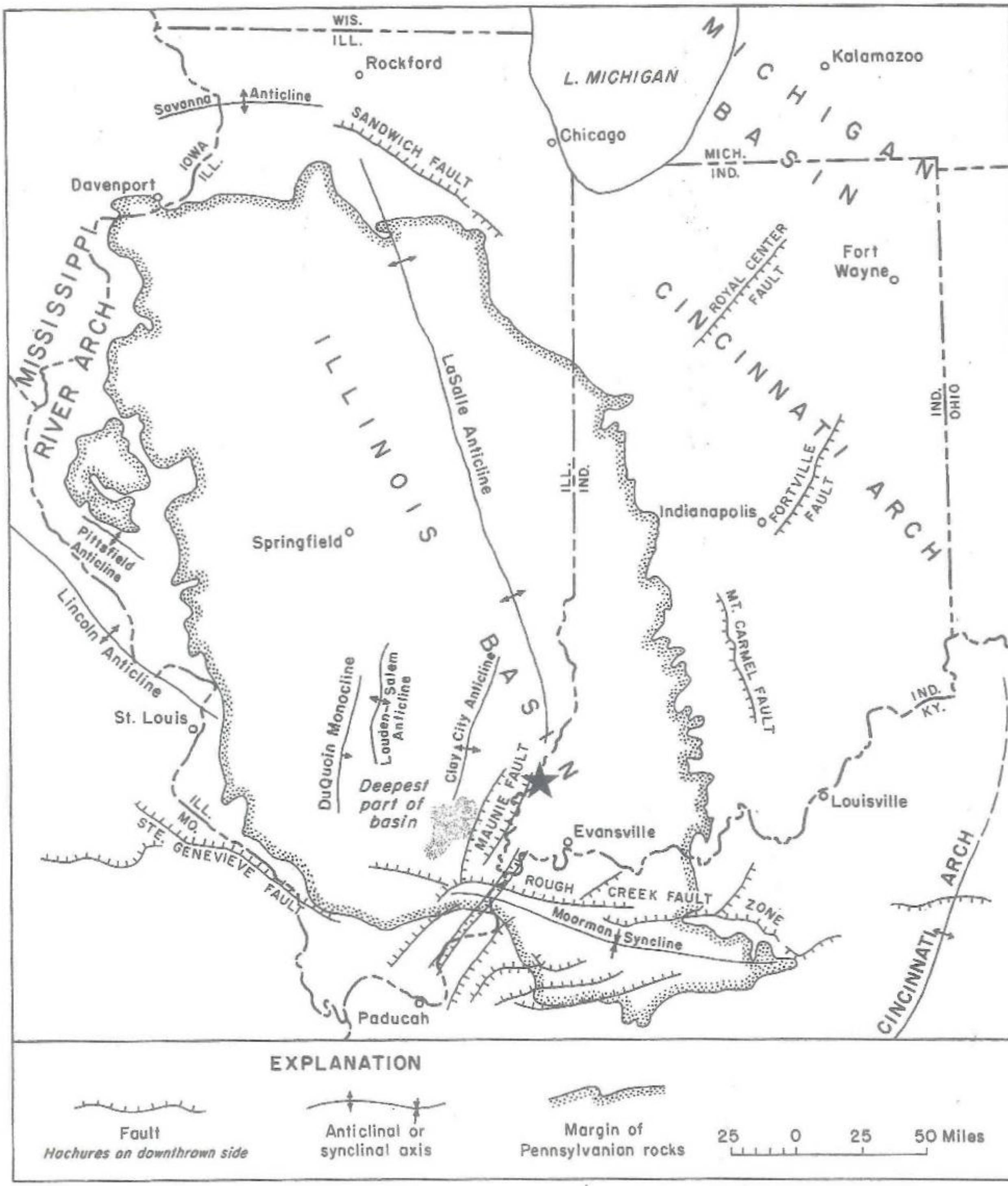
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP OF MIDWEST SHOWING
STRUCTURE OF THE AREA

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: RUDMAN AND RUPP, 1993



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-73

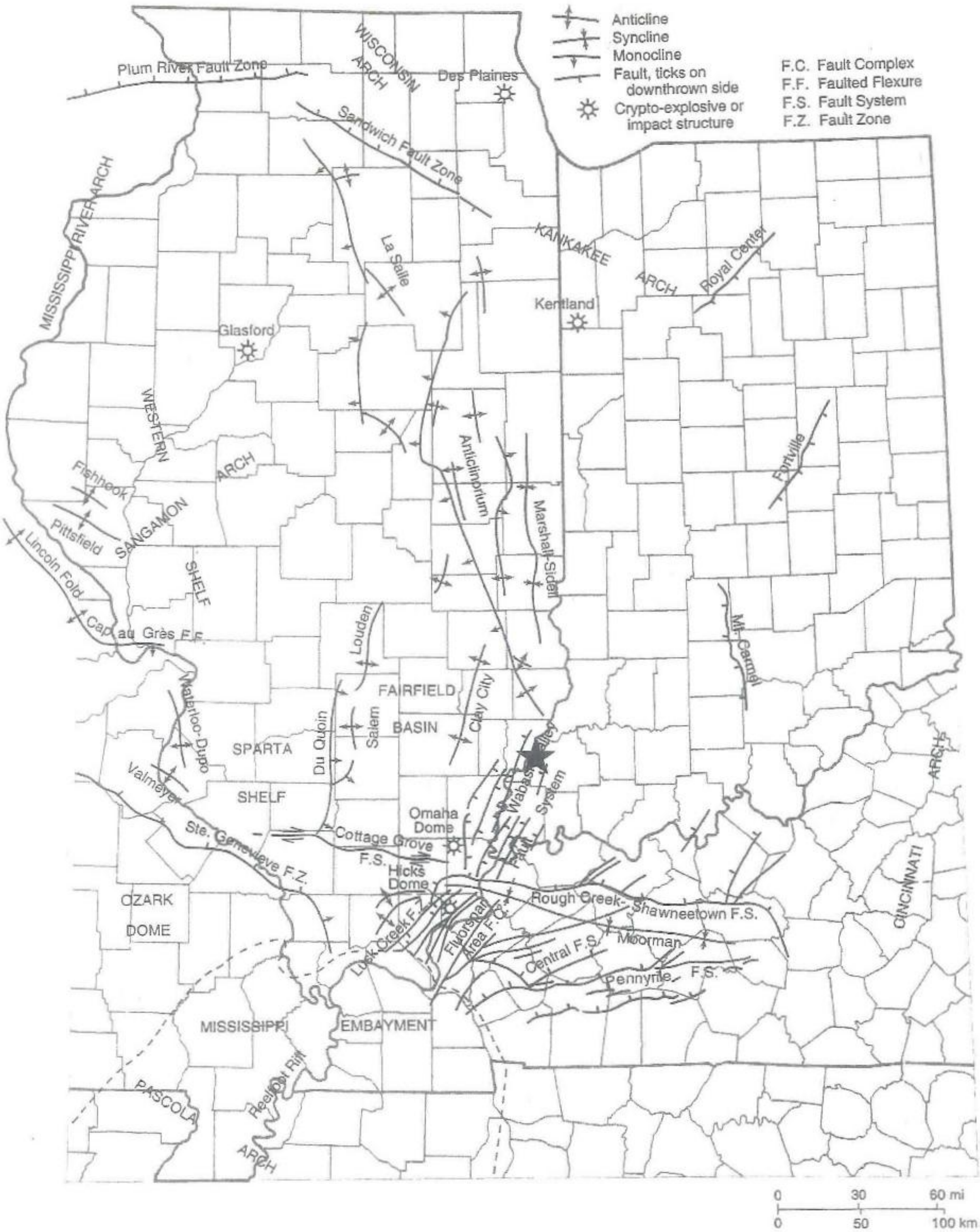
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAP OF AREA SHOWING
FAULTS AND STRUCTURAL FEATURES

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: SHAVER AND AUSTIN, 1972



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F-74

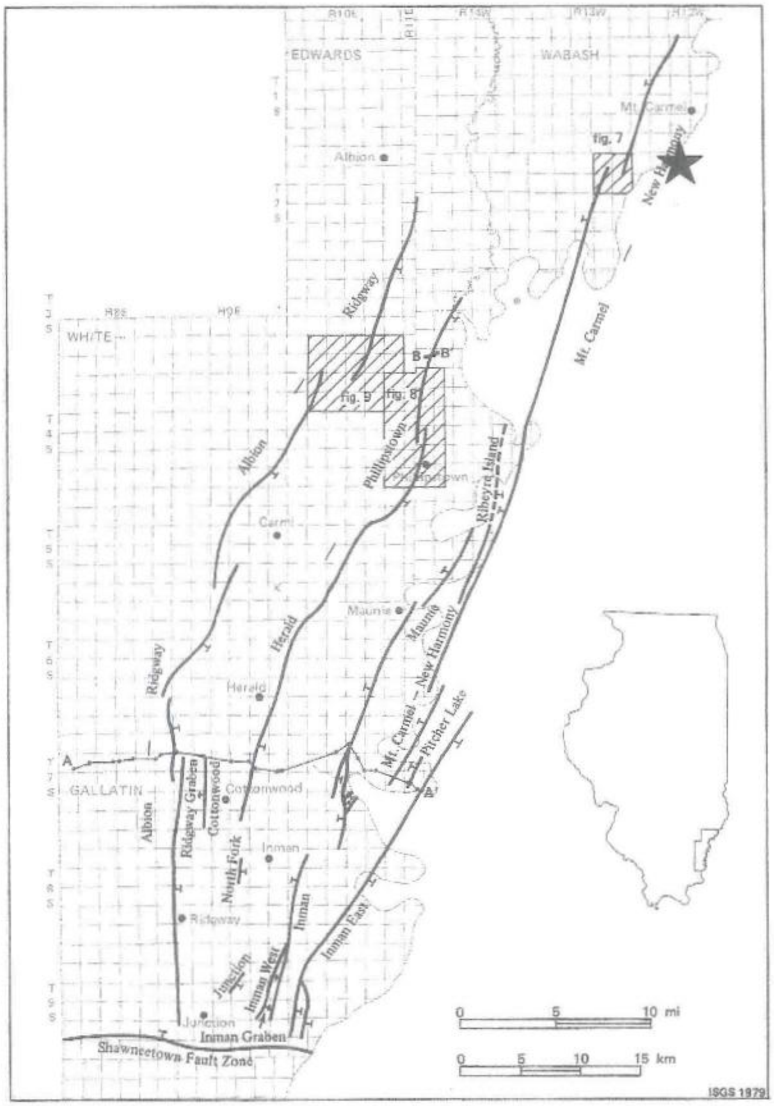
PSI ENERGY, INC.

GIBSON GENERATING STATION

MAJOR STRUCTURAL FEATURES IN ILLINOIS AND NEIGHBORING STATES

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: NELSON, 1995



LEGEND

★ SITE LOCATION

N

SUBSURFACE

HOUSTON, TX.
SOUTH BEND, IN.
BATON ROUGE, LA.

FIGURE F–75

PSI ENERGY, INC.

GIBSON GENERATING STATION

WABASH VALLEY FAULT SYSTEM
IN SOUTHEASTERN ILLINOIS

DATE: 1/26/05	CHECKED BY: RJS	JOB NO: 60D5675
DRAWN BY: CRB	APPROVED BY: RTB	DWG. NO:

SOURCE: BRISTOL AND TREWORGY, 1979

DRAWINGS

APPENDIX F-1

SUBSURFACE

National Earthquake Information Center (NEIC) Earthquake Search Results for a 100 Mile radius from the Proposed Bore Hole Location							
Year	Month	Day	Epicenter Latitude	Epicenter Longitude	Richter Scale Magnitude	Intensity (Mercalli)	Distance from Site (km)
1827	7	5	38	-87.5	4.8 FASC	6F..	24
1827	8	7	38	-88	4.7 FABAR	5F..	53
1827	8	7	38	-88	4.8 FASC	5F..	53
1838	6	9	38.5	-89	5.2 FASC	7F..	138
1850	4	5	37	-88	4.9 FASG	5F..	143
1857	10	8	38.7	-89.2	4.9 FASG	7F..	161
1876	9	25	38.5	-87.8	4.5 FASC	6F..	43
1876	9	25	38.5	-87.8	4.8 FASC	7F..	43
1887	2	6	38.7	-87.5	4.6 FASC	6F..	53
1887	8	2	37.2	-88.5	4.9 FASG	6F..	145
1891	7	27	37.9	-87.5	4.1 FASC	6F..	35
1891	9	27	38.25	-88.5	5.2 FASC	7F..	91
1899	4	30	38.5	-87.4	4.9 FASC	7F..	31
1921	3	14	39.5	-87.5	4.4 FASC	6F..	141
1922	11	27	37.8	-88.5	4.8 FASC	7F..	102
1925	4	27	38.2	-87.8	4.8 FASC	6F..	30
1925	9	2	37.8	-87.5	4.6 FASC	6F..	46
1958	11	8	38.44	-88.01	4.4 FASC	6F..	53
1968	11	9	37.91	-88.37	5.5 MnSLM	7F..	87
1973	1	7	37.44	-87.3	3.2 MnSLM	....	87
1974	4	3	38.55	-88.07	4.7 MnDG	6F..	64
1974	4	3	38.59	-88.09	4.7 MnSLM	6D..	69
1976	4	15	37.4	-87.31		5F..	91
1978	8	29	38.53	-88.22		F..	74
1978	6	2	38.42	-88.46	3.5 UKBLA	5F..	90
1978	12	5	38.62	-88.36	3.5 UKSLM	5F..	90
1980	3	23	37.63	-86.69	3.3 UKSLM	4F..	93
1980	3	13	37.93	-88.45	3 UKSLM	F..	93
1980	7	12	37.26	-86.99	3.1 UKPDE	3F..	113
1981	6	9	37.83	-89.03	3.5 MnSLM	5F..	144
1982	8	11	37.25	-88.73	3 MnGS	3F..	155
1984	6	12	38.92	-87.46	3.4 MnSLM	4F..	77
1984	4	17	38.38	-88.43	3.4 MnSLM	4F..	87
1984	6	29	37.7	-88.47	4.1 MnGS	6D..	106
1984	6	29	37.7	-88.47	4.1 MnGS	6F..	106
1984	7	28	39.22	-87.07	4 MnSLM	5F..	115
1984	8	29	39.37	-87.22	3.2 MnSLM	5F..	129

National Earthquake Information Center (NEIC) Earthquake Search Results for a 100 Mile radius from the Proposed Bore Hole Location

Year	Month	Day	Epicenter Latitude	Epicenter Longitude	Richter Scale Magnitude	Intensity (Mercalli)	Distance from Site (km)
1985	2	13	38.42	-87.51	3 MnSLM	....	22
1985	5	1	37.99	-87.63	2.9 MnSLM	.F..	29
1985	12	29	38.55	-88.96	3.5 MnGS	5F..	136
1986	10	29	38.44	-89.04	2.7 MnGS	3F..	140
1987	6	10	38.71	-87.95	5.1 MnSLM	6C..	69
1987	6	10	38.71	-87.95	5.2 MnSLM	6F..	69
1988	10	5	38.69	-87.93	3.6 MnSLM	4F..	66
1988	1	5	38.74	-87.96	3.3 MnSLM	4F..	72
1988	3	10	37.75	-88.83	2.6 MnTEI	.F..	131
1990	1	27	38.12	-86.44	3.8 mbGS	4F..	89
1990	1	24	38.13	-86.43	4.1 mbGS	5F..	90
1990	1	29	38.12	-86.42	2.9 MnGS	3F..	91
1990	10	24	38.31	-88.99	3.5 MnGS	4F..	134
1991	4	16	38.56	-87.99	3 MnGS	.F..	59
1991	11	11	38.71	-87.89	3.8 MnSLM	3F..	66
1991	1	23	37.95	-88.86	3 MnGS	5F..	126
1994	4	6	38.12	-89.27	3.1 MDSLM	4F..	159
1995	9	5	38.36	-89.04	2.9 MDSLM	4F..	139
1996	12	16	39.5	-87.4	3.1 MnGS	5F..	141
2000	3	6	38.1	-87.53	2.5 MnGS	.F..	15
2000	8	26	38.1	-87.28	2.6 MnSLM	....	20
2000	12	7	37.97	-87.66	4 MnSLM	4F..	32
2000	4	28	37.69	-88.42	2.9 MnGS	....	103
2002	6	18	37.99	-87.78	5 MnGS	6D..	38
2003	1	3	37.83	-88.07	3.1 MnSLM	3F..	69
2003	5	2	37.96	-88.65	3.1 LgSLM	.F..	108

UK = Unknown magnitude scale
Ms = Surface-wave magnitude; Bath, 1966
mb = Body-wave magnitude; Gutenberg and Richter, 1956
FA or MI = Felt area magnitude; approximately equivalent to an mb value
Mn = Nuttli magnitude; Nuttli, 1973
Lg = Lg seismic-waves (short-period surface waves)